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A COMPARATIVE POPULATION STUDY OF SMALL VERTEBRATES IN THE URANIUM AREAS OF THE UPPER COLORADO RIVER BASIN OF UTAH

by

Wilmer W. Tanner

Biological Series — Volume VII, Number 1

MAY, 1965

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PREFACE

This paper constitutes a terminal report to the United States Atomic Energy Commission for contract AT(11-1)819. It provides not only a faunistic and floristic study of areas having a high and low surface radiation, but also includes a consideration of their general ecology. Major emphasis is placed on the variation of the external characteristics of the small vertebrates of these areas with a statistical analysis of those characters examined in the lizards.

The study was conducted in southeastern Utah (Tanner 1963, see map) from October 1959 through 1964, and was conducted as a test of the variation effects of natural surface radiation on the external characteristics of small vertebrates.

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A COMPARATIVE POPULATION STUDY OF SMALL VERTEBRATES IN THE URANIUM AREAS OF THE UPPER COLORADO RIVER BASIN OF UTAH

INTRODUCTION

The discovery of uranium and vanadium ores in the Colorado Plateau area of Utah and Colorado near the turn of the century has finally led to a mining operation far beyond the dreams of those early prospectors who made their first ore shipments in 1902 (Sorensen: 282). In this early period of development of the area the ores were important because of the radium that could be extracted. Although the amounts obtained were small and the process of extraction was slow, tedious, and expensive, radium was extracted from Utah ores until 1923, with the greatest production occurring during the last ten years. During these few years the Colorado Plateau area of Utah and Colorado was the leading radium-producing area of the world. However, the processing of these ores was marginal and the discovery of high-grade ores in the Belgian Congo in 1923 made further operations too expensive.

During the first fifty years of development the area actually passed through three rather distinct mineralogical stages which may be represented as follows: (a) Radium to 1923. A sidelight of these early explorations is the shipping of carnotite ores from the San Rafael Swell fossiliferous deposits to Pierre and Marie Curie, in Paris, France, in 1903 (Boutwell 1905:207). At this same time the new yellow mineral was named Carnotite in honor of the French physicist Adolph Carnot. During this period the recovery of radium from the uranium ores placed this area in world prominence and produced more than 32 grams of radium in 1921. (b) Vanadium, 1923 to 1944, and (c) uranium, 1944 to present (Sorensen, 1963). In contrast to the preceding period, during the present period vanadium has been reclaimed as well as molybdenum even though uranium is now the primary product. A history of the development of this mining industry cannot be discussed further; however, for those interested the following studies provide some of the historical facts and cite additional references on this subject: Boutwell 1905, Sorensen, 1963, Hilpert and Dasch 1964. The latter is particularly valuable because of the large bibliography included in that study.

The explorations since 1945, however, have been much more extensive and intensive, thus providing a far greater knowledge of the size, quality, depth and extent of ore bodies throughout the entire plateau producing area of Utah and the adjoining states of Colorado, New Mexico, Arizona and Wyoming.

By the enormous numbers of claims throughout the area, the prospecting boom of the early 1950's demonstrated that uranium is widespread throughout the area. Although most of the established claims did not become producing mines because the ore was mostly of a low grade, the great extent of the natural ground level radiation particularly in "hot" areas was demonstrated.

Before leaving this aspect of the study it should be pointed out that three of the areas studied have been mined at various times for the past sixty years and are still producing, although not to any extent, from the same shallow deposits used in the early days. A general description of each area will serve as an orientation and as an introduction for necessary additional details. (Also see Hayward *et. al.* 1958.)

The first field work on this contract was begun on June 1, 1960, with two graduate assistants and me; thus the present investigations include four years of field work. It should be indicated at the outset, however, that most of the field work has been done and must be done during the summer months, primarily because we are dealing mostly with the cold-blooded vertebrates which are not available in these areas for more than about six months of the year.

The role of isolation in this inland desert basin must have played its part in providing an opportunity for variation to occur. The fact that so much variation does occur in most species of this area suggests that perhaps other factors may be operating. Few species occurring in the Upper Colorado Basin are of the same subspecies as those inhabiting the basins to the west (Great Basin), to the southeast (Upper Rio Grande) or to the south (Little Colorado). In fact, some variation has been observed be-

tween populations occupying opposite sides of the Colorado River in Utah.

Speciation, but more particularly subspeciation, has occurred regularly in the several valleys extending northward from the southern deserts. Such areas as Death Valley and those basins extending north, Lower Colorado Basin and the Virgin Valley in southwestern Utah, adjoining Arizona and Nevada and S. California and the Upper Colorado Basin are examples. One example of subspeciation found in this area is *Arizona elegans* with *candida* in the Death Valley area, *eburnata* in lower Colorado Basin and the Virgin Valley and *philipi* in the Upper Colorado Basin. The latter basin is particularly impressive in regard to the many subspecies present. Since several have been described and others discovered or recognized only recently, the Upper Colorado Basin has been of special interest to us, leading directly to the request for research funds to further investigate certain possible causes (Fig. 1).

It was hypothesized, therefore, that perhaps the numerous small areas of high surface radiation may be playing their parts by inducing variation into the populations of small vertebrates inhabiting these areas. Thus it was proposed that several areas in the Upper Colorado Basin with a higher-than-average surface radiation be studied and that local populations of small vertebrates (lizards, and if possible the small mammals) be compared for external morphological variations. It was further deemed necessary to compare populations occurring in the areas of high surface radiation (25 to 100 mr./hr.) with populations in the nearby or adjacent areas with a lower surface radiation (less than 20).

These comparisons consist of a series of character comparisons including external morphology, color and color pattern variations. In the lizards, scale count variations are most important, whereas in the mammals color and color pattern are used. An examination of the internal gross anatomy or histological comparisons is not included. Although physiological (including serological) and genetical (chromosomal cytology) studies may have been fruitful, the project was not designed to include internal cell or tissue variations.

The question of what is an unusual or noteworthy variation and when are such variations significant in small populations has been a ma-

FIG. 1. General view of the Temple Mountain study area, as viewed from north to south.

jor challenge throughout the course of this investigation. At the outset we postulated that there would be some variation and that these might take the form of, (a) an increase in the range of variation of a character within a single population or, (b) a skewing of the mean to the right or left of the means of other populations.

We realized at the outset that there was no certain way of determining the amount of radiation received by any one animal during a season or its life, and were therefore obligated to determine the general radiation for the area. From this we hoped to determine the average dosage for the animals included in the areas studied. Therefore, measured radiation listed in Table 12 represents the approximate dosage received per hour. Because there is uneven radiation, with some areas serving as pockets of high radiation and others of low, only the approximate or general area average is considered.

Although there have been many and varied studies carried forward to determine the effects of induced radiation on the inherited morphological characteristics of vertebrates, little is actually known about the effects of natural radiation on populations. A study by Daniel and Blair (1959) has indicated an increase of soil radiation in some areas of the San Luis Valley of southern Colorado. Ecological studies now in progress at Arco, Idaho, and Dugway, Utah, are primarily concerned with controlled induced radiation on native animals. Those ecological studies in the Atoll areas of the Pacific, at the Nevada test site, and other natural and laboratory areas represent environments where nuclear reactions have introduced radiation. In neither the ecological nor the many laboratory and field-controlled studies have the experimenters dealt with the major problems considered in this study.

During the first year four areas were selected, each of which is associated with an ore body and with an increase in surface radiation over adjoining areas. These were designated by the following names and will appear in this report as named here: Temple Mountain Mesa, Mamie Stover Incline, Yellow Cat area and Indian Creek area. The first two are located 45 and 15 miles respectively southwest and west of Green River, Emery County, Utah. The Yellow Cat area is approximately 15 miles southeast of Thompson's, Grand County; and Indian Creek is about 35 miles southwest of La Sal Junction, San Juan County, Utah. In the latter area only the reptiles are included in the variation studies (Fig. 2).

PROCEDURE AND ACKNOWLEDGEMENT

Several techniques were used in gathering the field data and to collect the animal samples. The mammals were caught in live traps, frozen in a field dry ice cabinet and returned to the University for mounting. Standard weights and measurements were taken, and the skins and skulls were prepared as is usual in museum collections. Previous studies (Brant 1962, Burt 1940, Calhoun and Casby 1958, Mohr and Stumpf 1964, and Tonaka and Teramura 1958), seemingly provide adequate home-range data to indicate that the species inhabiting these areas did not need additional home-range study. However, in the lizards I could not be sure; and since the areas under consideration are relatively small, it became mandatory that the extent of annual movement, at least, be determined for *Sceloporus undulatus elongatus*, *Uta stansburiana stansburiana* and *Cnemidophorus tigris septentrionalis*. These species were common to all areas studied. These were intensively studied only at Temple Mountain, the other areas not being included in the home-range studies. In each species the toe clip method was employed. An illustration of how the toes were counted is seen in Figure 3. After the first twenty lizards (*Uta*) were marked, two toes were clipped, such as 1 and 12 and the next series 2 and 15. Each lizard caught was marked, measured and the sex determined. Care was taken to release each lizard in the exact area where it was caught so that established home ranges would be less likely upset.

Lizards were caught by hand rather than by traps. This proved successful particularly with *Uta* and *Sceloporus* but was difficult for *Cnemidophorus*. In order to determine lizards and the exact spot taken the toe marks were recorded in the field book and at the same time painted on a rock, Figure 4. Thus a toe clip of five on the front foot and of 17 on the hind foot was recorded as 5-17. The painted marks on the rocks proved relatively permanent, thus making the measurement of distances between points of re-

FIG. 2. General view of the Mamie Stover area, showing a small ravine which cuts through the overlying cap rock.

capture easy. Second captures were recorded in the same way but with a line underscoring the figures. *Uta* were recorded as indicated; *Sceloporus* were recorded with an X following the figure (4-11X); and for *Cnemidophorus* the X was circled, 4-11Ⓧ

The methods of home-range study used in this project were in part dictated by the rough, rocky terrain but also from the fact that the pitfall trap method was being used for similar studies by Jorgensen and Tanner (1963) at the Nevada Test Site. Although the surface funnel traps have been used successfully by Fitch (1951 and 1960) in Kansas, the near absence of shade to protect captive lizards from the intense heat argued against their use.

In all other areas lizards were collected by using dust shot in .22 caliber pistols. This method proved highly successful in providing a relatively large series of specimens from the various areas. However, in most areas almost the entire population was taken in order to provide the needed series. At Temple Mountain because of the home-range study only a few lizards were taken until the summer of 1963. By shooting, a few specimens were damaged for one or two of the standard counts made, as reflected in the variable numbers used in the variation graphs, but the increase in specimens made available by

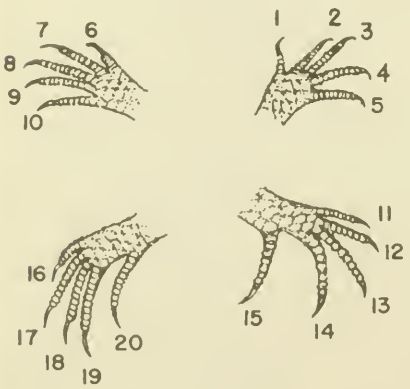


FIG. 3. Dorsal view of hands and feet of a *Sceloporus undulatus elongatus* showing the numbers assigned to the digits.

Fig. 4. Six views of the toe marks as recorded on rocks. All taken at Temple Mountain.

the method more than made up for the few losses.

In order to better evaluate the total environment a careful analysis of the kinds of plants, percentage of species in three areas, percentage of plant cover and soil depths were recorded. Here as with the lizards the plant species were first determined at Temple Mountain and then comparisons were made to determine variations between the areas. The plant canopy cover was determined by following a transect and placing a painted plot frame over the plants along every meter of the transect. While measuring the plant canopy, the soil depths were determined by using a steel penetrometer at regular intervals along the transect.

Various instruments have been used to detect an increase in ground level radioactivity. In this study, measurements of radioactivity were made in the field with a Tracerlab gamma scintillation detector, employing a 2" sodium iodide crystal. The equipment was powered by a portable 110-volt generator with a voltage regulator. The minimum counting time for each station was ten minutes. The equipment was standardized against known background rates at Provo, Utah, before and after use in the field. Supplemental measurements were made with a portable beta-gamma survey meter (geiger).

As previously indicated, some mining operations, either active or abandoned, occur in the areas. In our radiation measurements, these were avoided. Thus our data (Table 12) includes only those readings taken in the natural undisturbed habitat of each area studied.

I am indebted to the following for their assistance and for many helpful suggestions during the course of the project. These Graduate students have been responsible for much of the field work: W. Gerald Robinson, Robert E. Bullock, Lynn Findlay, Elden Willis, James Hopkin, Clyde Pritchett, and John Childs. Their devotion to the project, often under adverse desert conditions, is greatly appreciated.

The plants were collected by Verl Allman and Clyde Pritchett. Mr. Allman did the classification, with final designations of a few species being made by Dr. Stanley Welsh of the Brigham Young University, Botany Department. The mammals were examined by Dr. Stephen D. Durrant. To him I am grateful for helpful suggestions concerning the variations occurring between populations in these species.

I am grateful also to Dr. A. Lester Allen of the Brigham Young University, Department of Zoology and Entomology for the use of equipment and for the radiation measurements. Thanks is also extended to the field officials of the Union Carbide Company, who permitted us complete freedom of movement while at Temple Mountain.

GENERAL ECOLOGICAL BACKGROUND

Climate

The general climatic conditions for those parts of the Upper Colorado Basin included in this study are similar to those of the Great Basin of western Utah, which are at about 4,500 to 5,500 feet in elevation.

There are four weather stations in the general area (Hanksville, Green River, Thompson's, and Moab). These, except for Thompson's, are at lower elevations than the study areas and are therefore not completely representative of the climate. Although we have not been able to carry forward a year-round check of climatic conditions at the study areas, some summer maximums and minimums were taken at Temple Mountain. Both temperatures and humidity were obtained from an Abbeon indicator placed in a juniper tree about three and one-half feet above the ground surface and approximately at the middle of the area.

As is suggested by the low relative humidity of desert areas, there is only sporadic precipitation. Actually the climate is relatively moderate but with seasonal extremes. Temperatures range to above 100° F. in summer to 0° F. and below in winter; summer rains may be of the cloudburst variety, providing for heavy flooding, and heavy wind storms occasionally produce intense dust storms. Based on 30 or more years of Weather Bureau records for stations at Emery and Green River, Emery County; Hanksville, Wayne County; Moab and Thompson's; Grand County, Utah, the averages listed in Table 1 have been summarized.

Mr. E. Arlo Richardsen, State Climatologist at the Weather Bureau Airport Station, Salt Lake City, Utah, was kind enough to provide similar averages for the study areas. These he calculated by using the data available from the nearest weather station and used the differences in elevation, slope and sun exposure to provide an es-

Table 1. Temperature and precipitation averages for five weather stations in Emery and Grand Counties, Utah for 30 or more years.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Emery													
Daily Maximum	36.0	40.5	49.2	59.5	67.9	76.8	83.3	80.6	73.9	62.7	48.4	37.9	59.7
Daily Minimum	11.7	16.4	23.8	31.5	39.2	46.3	53.5	51.5	43.8	34.2	22.6	15.1	32.5
Monthly Mean	23.9	28.5	36.5	45.5	53.6	61.5	68.4	66.1	58.9	48.4	35.5	26.5	46.1
Mean Precipitation	0.51	0.43	0.52	0.36	0.61	0.56	0.77	1.27	0.78	0.73	0.30	0.53	7.41
Green River													
Daily Maximum	38.0	48.1	59.6	71.1	81.5	91.7	98.9	95.9	87.5	73.0	53.8	42.2	70.1
Daily Minimum	9.3	18.1	26.1	36.0	44.6	52.1	60.1	58.0	47.7	35.2	20.8	14.5	35.2
Monthly Mean	23.7	33.1	42.9	53.6	63.1	71.9	79.5	77.0	67.6	54.1	37.3	28.4	52.7
Mean Precipitation	0.36	0.39	0.40	0.43	0.38	0.44	0.51	0.82	0.52	0.70	0.38	0.45	5.78
Hanksville													
Daily Maximum	38.8	48.5	60.4	71.1	81.0	91.5	96.7	93.6	85.0	72.4	57.5	44.0	70.0
Daily Minimum	8.2	17.9	27.1	34.7	42.8	51.4	58.9	55.5	46.5	33.8	20.7	12.7	34.2
Monthly Mean	23.5	33.3	43.7	53.1	61.9	71.5	77.9	74.6	65.7	53.1	39.1	28.4	52.2
Mean Precipitation	0.37	0.30	0.32	0.29	0.35	0.39	0.71	0.77	0.54	0.68	0.27	0.36	5.35
Moab													
Daily Maximum	42.3	50.2	61.2	72.8	81.9	91.6	98.4	95.2	86.9	74.3	56.2	44.8	71.3
Daily Minimum	17.3	23.4	31.2	40.5	57.6	55.4	62.3	59.8	51.1	39.1	26.5	19.9	39.5
Monthly Mean	29.8	36.8	46.2	56.7	64.8	73.5	80.4	77.5	69.0	56.7	41.4	32.4	55.4
Mean Precipitation													9.00
Thompson's													
Daily Maximum	36.6	44.7	55.8	66.9	77.5	87.8	94.4	91.6	82.4	70.0	54.7	40.9	66.9
Daily Minimum	12.9	21.5	29.2	36.9	46.2	54.4	62.2	60.4	50.4	38.6	25.8	17.2	38.0
Monthly Mean	24.8	33.0	42.6	51.9	62.0	71.1	78.5	76.1	66.4	54.2	40.3	29.2	52.5
Mean Precipitation	0.59	0.56	0.73	0.67	0.51	0.51	0.85	0.90	0.97	1.10	0.49	0.72	8.60

timation. These calculated averages are listed in Table 2.

An examination of Tables 1 and 2 indicates that perhaps the most important factor contributing to the differences in temperature, not only at the weather stations but also at the study areas, is the difference in elevation. However, these elevation differences in temperature do not appear when comparing all stations; for example, Hanksville weather station at 4450 ft. contrasted with Thompson's station at 5150 ft. varies less than one degree for the annual temperature. Other factors, air drainage, seasonal precipitation, slope, etc. must influence temperature as well as elevation.

Precipitation is sporadic and basically represents a continental and dry climate. The area as a whole has from 6-10 inches of precipitation

Table 2. Temperature averages and precipitation totals for three study areas in Emery and Grand Counties, Utah.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
San Rafael (Mamie Stover)													
Daily Maximum	40.0	47.0	57.8	68.7	78.5	88.6	93.9	91.9	83.7	71.3	55.3	43.9	68.3
Daily Minimum	9.4	16.6	24.4	32.7	40.3	48.6	56.3	53.9	45.1	32.7	18.5	12.7	32.7
Monthly Mean	24.7	31.8	41.1	50.7	59.4	68.6	75.1	72.9	64.4	52.0	36.9	28.3	50.5
Mean Precipitation													6.00
Temple Mountain													
Daily Maximum	37.2	41.5	50.5	60.9	69.8	79.0	85.6	83.0	76.3	64.3	49.4	39.7	61.4
Daily Minimum	12.8	17.3	25.1	32.9	41.0	48.6	55.8	53.8	46.1	35.9	23.6	16.9	34.1
Monthly Mean	25.0	29.4	37.8	46.9	55.4	63.8	70.7	68.4	61.2	50.1	36.5	28.3	47.8
Mean Precipitation													8.50
Yellow Jacket Wash													
Daily Maximum	38.7	44.7	56.5	67.4	77.3	88.2	94.7	91.7	84.2	71.3	54.0	42.1	67.4
Daily Minimum	15.1	21.3	30.1	37.4	46.3	54.8	62.9	60.7	52.2	39.7	25.2	18.7	38.6
Monthly Mean	26.9	33.0	42.0	52.4	61.8	71.5	78.8	76.2	68.2	55.5	39.6	30.4	53.0
Mean Precipitation													7.00

during the year. Thunder storms during July and August provide more rainfall than for any other period. Both Moab and Thompson's report more precipitation than the station at Green River and those stations to the west. This may reflect the Colorado River air drainage or the influence of the Rocky Mountains to the east in Colorado.

In summary, the climatic conditions in the general area where this study was made are surprisingly similar, particularly if the annual averages are considered as the basic criteria.

GENERAL DESCRIPTION OF THE AREAS

After having carefully examined the selected areas, I became apprehensive of the role played by plant cover, soil types and soil depths. Each of these may be a determining ecological factor in any natural system where conditions might produce an increase of variation in a gene pool. It is not seemingly possible to rule out the probable effects which may be produced by such environmental factors in disjunct but similar areas. Therefore, in order to establish the extent of physical and biological factors within the areas, we determined in a general way the plant species in each area and their approximate percentage of surface cover. We also determined the soil depth and general composition. Although there are some slight variations, both in kinds of plant species found and the depth of the soil mantle, these may represent fluctuations which would be expected to occur as a result of random sampling.

Temple Mountain Mesa. The Temple Mountain area consists of a small ridge extending for approximately one thousand yards north and south and varying in width from approximately one hundred yards to slightly over two hundred yards near its middle. This formation is adjacent to and just west of the eastern uplift of the sandstone of the San Rafael Reef. The western edge of the Temple Mountain area consists of a ledge of white limestone-conglomerate cap rock dipping to the east and forming a natural barrier on the western edge. The narrow northern boundary lies along a fault, with the area to the north uplifted and sloping up to the base of Temple Mountain.

This study site lies at an elevation of about 5,500 feet. It, as well as the Mamie Stover area, lies along the eastern edge of the San Rafael Swell. Both fall within the influence of a desert climate similar to that of the Great Basin Desert —that is, they are both characterized by low rainfall and atmospheric humidity, hot sunny days, a great daily range of temperature, intermittent streams, high salt content of the soil and other desert environmental features. Immediately to the east (one mile from study area) is the San Rafael Desert. Leaching of desert soils proceeds very slowly because of the low rainfall; hence, surviving species must be able to tolerate the highly alkaline soils usually present in such areas. The two plant communities most widespread in the Great Basin Desert are those in which sagebrush *Artemisia tridentata* Nutt. and shadscale *Atriplex confertifolia* (Torr. and Frem.) S. Watts. are the dominant plants. *Atriplex* is found in the more alkaline soils.

The area slopes from north to south, with a low hill on the western edge and the high reef to the east, giving the hillsides of the study area essentially a southeastern exposure. A fairly large wash drains the area from north to south, with smaller washes draining into it from the slopes to the west and north. No measurements of the precipitation were taken within the study area, but records at the city of Green River nearby show an average precipitation of 5.78 inches falling throughout the year but with the greatest amounts during the months of July, August, and September. Precipitation, however, is very erratic in such environments and significant variations occur from year to year.

Besides the dominant *Atriplex confertifolia* the hillsides are covered with a great variety of herbaceous and shrubby plants. Many annual and perennial grasses are found in scattered clumps with *Oryzopsis hymenoides* (Roem. and Schult.) being more abundant but with ephemerals abundant on the slopes in the springtime. The latter germinate, grow rapidly and mature in the span of a few short weeks. These include various species such as *Lepidium densiflorum* Schred., *Lepidium montanum* Nutt., *Streptanthus longirostris* S. Watts., *Euphorbia fendleri* Torr. and Gray, *Oenothera caespitosa* Nutt., *Oenothera multijuga* Watson, *Oenothera walkeri* (A. Nelson), *Gilia gracilis* (Dougl.) Hook, *Descurainia sophis* (L.) Webb, *Lappula redowskii* (Hornem.) Greene, *Plantago purshii* Roam. and Shult., *Lygodesmia exigua* (Nutt.) Greene, and others. (See plant list.)

In addition to the dominant *Atriplex* there are a number of other shrubs. Some of these are *Ephedra viridis* Coville, *Cercocarpus intricatus* S. Wats., *Cowania stansburiana* Torr., *Amelanchier utahensis* Gatt. Pomac., *Rhus trilobata* Nutt. Torr. and Gray, *Rhus utahensis* Godding, *Artemisia tridentata* Nutt., *Chrysothamnus nauseosus* (Pall.), *C. viscidiflorus* (Hook) Nutt., *Tetradymia glabrata* A. Gray, and an occasional *Opuntia rhodantha* Schumann, Gesamtb.

Many species of plants typical of areas of higher rainfall are found adjacent to desert washes. Found chiefly near the wash in the study area are occasional small trees of the Pinon-Juniper Association which is so typical of the intermountain region, *Pinus edulis* Engelm, and *Juniperus utahensis* (Engelm). Confined mainly to the wash are other species such as *Amelanchier utahensis* Koehne, Gatt. Pomac, *Fraxinus anomala* Torr. S. Wats., *Rhus trilobata* Nutt. Torr. and Gray, *Rhus utahensis* Godding, *Astragalus spp.*, *Cowania stansburiana* Torr., *Salsola kali L.*, *Cercocarpus intricatus* S. Wats. and *Symphoricarpos oreophilus* A. Gray.

Significant among the plants of the area are those that serve as indicators. R. F. Nelson (1957) reports that "in every case investigated, Beath, Eppson and Gilbert found *Stanleya pinnata* growing on seleniferous soils in 11 western states." The use of *Stanleya pinnata* as an indicator of selenium is confirmed by many writers since it is found to occur almost exclusively on selenium bearing soils. This plant is common throughout the area.

Even more significant to this study is the work of Helen Cannon (1952). She found that uranium ores of the Colorado Plateau contained not only uranium but also considerable quantities of vanadium and selenium, and that these elements were absorbed in unusual amounts by the roots of plants growing in these areas. She states: "A much higher content of uranium has been reported by the Canada Department of Mines . . . in plants growing in the vicinity of pitchblend deposits. Plants growing on the asphaltic sandstone deposits at Temple Mountain, Utah, and on limestone deposits at Grants, New Mexico, also absorb uranium readily. The maximum values are considerably higher than those found in plants associated with carnotite deposits of the Colorado Plateau." She gives (Table 3) the following analysis of the Asphaltic sandstone, Shinarump conglomerate, and organic materials of the Temple Mountain area and for the carnotite ore of Yellow Cat study site.

Thus we have a variable in the amounts of minerals taken up by plants. When one considers the availability of uranium in plants which are used as food either directly or indirectly (eaten directly as in the case of rodents or indirectly as in the case of lizards eating plant-feeding in-

Table 3.[1] Analyses of Plants Growing on Uranium-bearing Rocks and Soils of the Colorado Plateau 1949-50°

Locality and Sample	Ash (per cent)	U		V_2O_5 PPM		Se	
		Soil or rock	Plant ash	Soil or rock	Plant ash	Soil or rock	Plant ash
Temple Mountain, Utah							
Asphaltic ss. ore, Shinarump conglomerate	.....	760		1,500		0.8	
Wood in ore		4,900		7,800		3.0	
Juniperus monosperma tops	4.0		66		350		n.d.
Juniperus monosperma tops	4.0		100		470		n.d.
Oryzopsis hymenoides tops	5.5		20		260		10
Stanleya pinnata tops	10.0		37		120		190
Sta. 1 Yellow Cat area, Thompson's District, Utah							
S. 2 Sandstone near carnotite ore	.....	20	.....	2,200	.....		.....
°°P. 8 *Oryzopsis hymenoides*—tops	7.3	.....	30	.....	70		.....
Oryzopsis hymenoides—roots	35.2	.....	40	.....	1,600		.....
S. 3 Surface soil 5 ft. above carnotite ore	.....	2	.....	180	.....		.....
S. 4 Shale layer in ore	.....	290	.....	23,000	.....		.....
P. 10 *Ephedra viridis*—tops	14.7	.....	2	.....	20		.....
P. 12 *Atriplex confertifolia*—tops	31.3	.....	2	.....	50		.....
P. 56 *Artemisia spinescens*—tops	18.4	.....	3	.....	70		.....
Artemisia spinescens—roots	13.2	.....	5	.....	100		.....

[1]Adapted from Cannon 1952, Tables 6 and 8.
°F.S. Grimaldi, Ruth Kreher, Claude Huffman, and F. N. Ward, chief analysts.
°°Selenium-indicator plants

sects), the problem of determining radiation source becomes more complicated and its effects more difficult to determine.

The size of this area (approximately thirty-five acres) has provided a sufficiently large population of small vertebrates to make a variation study possible. This has been the area in which we have conducted all of our studies dealing with home range in the lizards.

Approximately two miles west of Temple Mountain are two areas represented by small drainage ravines, both showing a reduced radiation count, which have been used for the securing of comparative specimens. Each of these areas, designated as upper and lower ranges, represents approximately one half of the area at Temple Mountain, and has been intensely collected. In both of these areas the ore-bearing strata have been eroded away. They are, however, at approximately the same elevation as the Temple Mountain Mesa because of the San Rafael Swell uplift and the accompanying erosion. Even though there are some slight differences in the soils, it appears to support the same general type of plant cover and to represent approximately the same percentage of plant canopy-cover when compared with the Temple Mountain Mesa Area.

Mamie Stover Area. This area is located in the Northeastern edge of the San Rafael Swell, but lies just east of the San Rafael Reef. Overlying this area is a cap rock varying from five to seven feet in thickness. Embodied in the cap rock are a series of fossil trees. Much of the radioactive ore is associated with these fossils, and in some instances rather high grade pockets have been mined. Erosion has cut a series of channels through the cap rock. Other areas are partly eroded. This, plus the fact that small cracks and crevices have developed in the cap rock, has provided for a high surface gamma radiation in this area (Table 12). In some areas where erosion has exposed the fossilferous material the ore is at the surface and actually provides for the highest ground-level radiation found in any of the areas under investigation. The basic nature of the cap rock provides only for small pockets for vegetation development other than what is found in the larger ravines. Thus, there is an obvious bareness in this area which is not apparent in the other areas. Transects were taken in the more vegetated areas and therefore the figures in Table 5 do not reflect accurately the area as a whole but rather the vegetated pocket areas where the animals live.

Yellow Cat Area. This area is approximately fifty-five miles east of the San Rafael Reef and fifteen miles Southeast of Thompsons, Grand County, Utah. We have examined the area lying south of the first (east) junction and west of the road along the base of a ledge area in which is found pockets of uranium and vanadium ores. This area is approximately one half mile long, but not more than one hundred yards wide at any place. Because of its basic geological nature and based on our data gathered at Temple Mountain, it is considered that the small vertebrates are rather restricted to this narrow belt. The general area is less variable in altitude, with fewer high ridges and deep valleys. The elevation is perhaps a few hundred feet below that of the other two areas (according to Cannon, 4,900 ft.), but does support approximately the same plant and animal species. Much of the data gathered by Cannon (*loc. cit.*) indicates that approximately the same plant species occur here as in the San Rafael Swell areas.

Indian Creek Area. This is a small area at the bottom of a rather large canyon. Erosion has exposed the ore-bearing strata so that they are exposed on each side of the small creek for a short distance. The greatest contrast here is in the greater abundance of vegetation, particularly along the stream. The apparent increase in plant cover is seemingly reflected by the more dense lizard populations, particularly in *Cnemidophorus tigris*.

REVIEW OF THE OBJECTIVES

In order to be more explicit, each of the four original objectives will be summarized with as much detail as the data will permit. The objectives as originally listed have required some modifications. Perhaps the most significant of these is the inclusion of the basic plant ecology and of soil depths for the major areas listed above. Most of this will be included as a part of the first objective.

Objective 1. Determine kinds of populations of vertebrates occurring in these natural radiation areas as compared with nearby nonirradiated areas. (The word *nonirradiated* should be

changed to read low surface radiation, since all areas show some surface radiation.)

A. **Cold-Blooded Vertebrates.** Three species of lizards are relatively common throughout the area (*Uta stansburiana subsp.*, *Sceloporus undulatus elongatus*, and *Cnemidophorus tigris septentrionalis*). Other reptiles taken in limited numbers are these: a few specimens of *Crotaphytus collaris*, *Crotaphytus wislizeni*, *Urosaurus ornata*, *Masticophus taeniatus* and *Crotalus viridis concolor*. Amphibians have been found at Mamie Stover and at Yellow Cat. In both instances only a few individuals of *Bufo punctatus* and *Bufo woodhousi* were taken, and they are not therefore being included in the project study.

B. **Warm-Blooded Vertebrates.** Seven species of mammals were found to be most abundant in the study areas. Phylogenetically they are as follows: *Ammospermophilus leucurus*, *Eutamias quadrivittatus*, *Peromyscus crinitus*, *Peromyscus maniculatus*, *Peromyscus truii* and *Neotoma lepida*. Other species taken but not in sufficient numbers to justify variation studies are *Dipodomys ordii*, *Neotoma cinerea*, *Lepus* sp. and *Sylvilagus* sp. Signs of large carnivores of both canids and felids were observed in all areas.

A more detailed comparative study of the populations of each species will be made later; however, the skin and skull material available for study is listed in Table 4 for each area studied. This material is now available at the Brigham Young University Museum.

Those listed from Temple Mountain Mesa were taken during the late summer and fall of 1960. They appeared to be abundant, and we were therefore selective, taking only a small sample of adults. For reasons not fully understood by us, all small mammals disappeared during the winter of 1960-61. In June of 1961 we did not trap a single mammal. An investigation of the wood rat (*Neotoma*) nests revealed no live inhabitants, but did provide several skeletons. It is our guess that we experienced a local crash cycle which eliminated the Temple Mountain populations. We did not notice a reduction in populations at other areas, although there was not a large population of any mammal species at Mamie Stover.

Also of importance was the apparently complete elimination of all small mammals in the nearby upper and lower ranges. There are therefore no comparative mammals from these areas.

The geographical extent of this "crash" was not determined. It did not affect those populations at Mamie Stover or at Yellow Cat, but was so complete at Temple Mountain that no small mammals were seen or trapped during the summer of 1961 and only a few chipmunks were seen in 1962 and 1963.

C. **Plant Species and Vegetation Analysis.** The vegetation was analyzed in all areas being studied in order to determine the dominant plant species within each area.

The canopy-cover was determined by following a transect and placing a pointed plot frame over the plants along the transect every meter. The purpose of using this method was to obtain a two-dimensional evaluation of the influence each plant taxon exerts over the other components of its ecosystem. All of the individuals of one taxon that fall within the plot frame are considered as a unit. An imaginary line is drawn around the leaf tips and projected onto the ground. The taxon is then placed into a cover class according to the percentage of the plot frame the imaginary polygon covers. The remaining taxa within the plot frame are then

Table 4. Lists of mammal species taken at three of the study areas.

Species	No. of Specimens
TEMPLE MOUNTAIN MESA, EMERY COUNTY	
Ammospermophilus leucurus	18
Eutamias quadrivittatus	13
Dipodomys ordii	1
Peromyscus crinitus	4
Peromyscus maniculatus	20
P. truii	4
Neotoma lepida	8
	68
MAMIE STOVER, INCLINE, EMERY COUNTY	
Ammospermophilus leucurus	2
Eutamias quadrivittatus	5
Peromyscus crinitus	6
Peromyscus truii	1
Neotoma lepida	15
	29
YELLOW CAT MINING DISTRICT GRAND COUNTY	
Ammospermophilus leucurus	23
Eutamias quadrivittatus	15
Dipodomys ordii	2
Peromyscus crinitus	9
Peromyscus maniculatus	3
Peromyscus truii	4
Onychomys leucogaster melanophrys	6
Neotoma lepida	13
Neotoma cinerea	3
	81

TABLE 5. Five dominant plants in the Temple Mountain, Mamie Stover and Yellow Cat Areas.

Temple Mountain		Mamie Stover		Yellow Cat	
Taxon	Percent Composition	Taxon	Percent Composition	Taxon	Percent Composition
Hilaria jamesii	28.00%	*Hilaria jamesii*	26.48%	*Hilaria jamesii*	27.50%
Oryzopsis hymenoides	20.50%	*Cowania stansburiana*	13.20%	*Gutierrezia sarothrae*	8.10%
Ephedra viridis	14.00%	*Rhus trilobata*	11.05%	*Oryzopsis hymenoides*	7.35%
Atriplex confertifolia	11.00%	*Stipa speciosa*	8.90%	*Atriplex sp.*	7.16%
Eriogonum inflatum	6.40%	*Artemisia tridentata*	8.75%	*Sphaeralcea parvifolia*	7.02%
	79.90%		68.38%		57.13%

added together, which results in an approximation of the total plant canopy-cover for the area being studied.

The plant canopy-cover at Temple Mountain Mesa was 21 percent, leaving about 78 percent of the ground surface bare. Thirty-seven different plant species formed this cover percentage. However, four plant species, *Hilaria jamesii, Oryzopsis hymenoides, Ephedra viridis,* and *Atriplex confertifolia,* respectively were the dominant plants. Together they formed 72 percent of the total plant cover.

At the Mamie Stover area the canopy-cover was 23.71 percent, leaving about 76 percent of the ground bare, mostly exposed standstone and limestone. Here *Hilaria jamesii* was the dominant plant species, followed closely by *Cowania stansburiana, Rhus trilobata,* and *Stipa speciosa* respectively.

The plant cover at the Yellow Cat Mine appears to be greater than the two previous areas, 33.58 percent. This was not exactly a random sampling, because the transects were taken at the base of the ledges and through the valley. *Hilaria jamesii* was still the dominant plant, with *Gutierrezia sarothrae, Oryzopsis hymenoides,* and two species of *Atriplex* making up about 50 percent of the plant cover.

The five most dominant plant species for each area and the percentage of composition of each are listed in Table 5.

In order to determine the percentage of plant cover at the study sites a complete list of the plant species for each area, excepting Indian Creek, was made. There are a few different species in each list, but since there is considerable duplication only the complete list for the Temple Mountain area is presented.

In 1964 Harrison, Welsh and Moore published a complete list of the plant species occurring in the Arches National Monument. Since the Yellow Cat area is only a few miles north of the Arches Monument, I suggest that those desiring more information on the Yellow Cat flora use their list of plants.

In all the areas the plant cover forms an integral part of the cover for the small saurians and provides a habitat for the insects which in turn serve as food for most lizards.

The composition of the soil was either clay, sand, or a mixture of the two, depending on the surrounding geological formation. The rocks on the surface of the soil provide shelter for most of the small vertebrates. A penetrometer reading was taken at each point where the flora was sampled to determine the relative stoniness and hardness of the soil.

TABLE 6. List of the plant species taken at the Temple Mountain study area and arranged alphabetically by families.

PLANT SPECIES COLLECTED

Anacardiaceae.
- *Rhus trilobata* (Nutt.) T. and G.
- *Rhus utahensis* Godding

Boraginaceae.
- *Cryptantha* sp.
- *Cryptantha crassisepala* (T. and G.) Greene
- *Cryptantha flava* (A. Nels.) Payson
- *Descurainia spohia* (L.) Webb
- *Lappula redowskii* (Hornem.) Greene

Cactaceae.
- *Opuntia rhodantha* Schumann. Gesamtb.

Caprifoliaceae.
- *Symphoricarpos oreophilus* A. Gray

Chenopodiaceae.
- *Atriplex confertifolia* (Torr. and Fram.) S. Wats

Compositae
- *Artemisia tridentata* Nutt.
- *Aster* sp.
- *Aster arenosus* Blake
- *Aplopappus acaulis* (Nutt.) A. Gray
- *Brickellia longifolia* S. Wats.
- *Chaenactis stevioides* Hook and Arn.
- *Chrysopsis villosa* (Pursh) Nutt.
- *Chrysothamnus nauseosus* (Pall.) Britton
- *Chrysothamnus viscidiflorus* (Hook) Nutt.
- *Laphamia stansburii* A. Gray
- *Lygodesmia exigua* (Nutt.) Greene
- *Lygodesmia juncea* (Pursh) D. Don
- *Tetradymia glabrata* A. Gray
- *Thelesperma subnudum* A. Gray
- *Townsendia incana* A. Gray

Cruciferae.
- *Lepidium densiflorum* Schrad.

Lepidum montanum Nutt.
Malcolmia africana (L.) R. Br.
Physaria australis (Payson) Rollins
Stanleya pinnata (Pursh) Britton
Streptanthella longirostris S. Wats.
Euphorbiaceae.
Euphorbia fendleri T. and G.
Gnetaceae.
Ephedra viridis Coville
Gramineae.
Agropyron inerme (Schribn. and Smith) Rydb.
Agropyron smithii Rydb.
Aristida longiseta Steud. Syn.
Bouteloua gracilis (H.B.K.) Lag.
Bromus tectorum L.
Hilaria jamesii (Torr.) Benth
Oryzopsis hymenoides (Roem. and Schult.)
Sitanion hystrix (Nutt) J. G. Smith
Sporobolus cryptandrus (Torr.) A. Gray
Stipa columbiana Macoun.
Stipa comata Trin and Rupr.
Stipa speciosa Trin. and Rupr.
Tridens pulchellus (H.B.K.) Hitch.
Hydrophyllaceae.
Phacelia crenulata Torr.
Leguminosae.
Astragalus flavus (Nutt.) T. and G.
Astragalus lentiginosus palans (Dougl., Jones, Hook)
Astragalus praelongus Sheld.
Loasaceae.
Mentzelia albicaulis Doug.
Malaceae.
Amelanchier utahensis Koehne, Catt. Pomac
Malvaceae.
Sphaeralcea coccinea (Pursh) Britton
Nyctaginacese.
Albronia elliptica A. Nels.
Allionia linearis (Pursh)
Onagraceae.
Oenothera caespitosa Nutt.
Oenothera multijugas Wats
Oenothera walkeri (A. Nels.) Raven
Oleaceae.
Fraxinus anomala (Torr.) S. Wats.
Pinaceae.
Pinus edulis Engelm.
Plantaginaceae.
Plantago purshii Roem. and Schult.
Polemoniaceae.
Gilia gracilis (Dougl.) Hook.
Polygalaceae.
Polygala subspinosa S. Wats.
Polygonaceae.
Eriogonum bicolor Jones
Eriogonum fasciculatum Benth.
Eriogonum hookeri S. Wats.
Eriogonum inflatum Torr.
Eriogonum pusillum T. and G.
Rosaceae.
Cercocarpus intricatus S. Wats.
Cowania stansburiana Torr.
Scrophulariaceae.
Penstemon utahensis Æastw.

The penetrometer is a pointed steeel rod, about one-half inch in diameter and ten decimeters long. A short pipe welded on one end makes it possible to push the penetrometer into the soil. The depth is measured to the nearest decimeter.

The relative stoniness was greatest at the Mamie Stover area; the average soil depth is 1.1 decimeters. At Temple Mountain the average soil depth, 1.2 decimeters, was slightly greater than at Mamie Stover. The soil depth at Yellow Cat was much greater than that in the two previous areas. Here the soil depth was 2.9 decimeters. The minimum, maximum, mode and average soil depths are listed in Table 7.

Table 7. Soil Depth Data for Temple Mountain, Mamie Stover and Yellow Cat Areas. Measurements are in Decimeters.

Temple Mt.		Mamie Stover		Yellow Cat	
Min.	0. dm.	Min.	0. dm.	Min.	0. dm.
Max.	5. dm.	Max	5. dm.	Max.	9. dm.
Mode	1. dm.	Mode	0. dm.	Mode	3. dm.
Ave.	1.2 dm.	Ave.	1.1 dm.	Ave.	2.9 dm.

Objective 2. Determine the approximate home range, seasonal distribution and migration of individuals in these areas.

In the area here designated as Temple Mountain, we have toe marked over four-hundred lizards. During the summer of 1960 (June 1 to September 1) marked ones were also recaptured in the course of capturing for marking. However, most recaptures were made during the summer of 1961, with some being made during 1962 and 1963. Figures 5 and 6 provide the approximate shape and size and indicates home ranges of a few *Uta* and *Sceloporus* of the Temple Mountain area.

Tables 8, 9, and 10 provide data from which the home ranges are determined. Other useful data (to be discussed below) such as size, rate of growth and longevity are also indicated in these data.

Many *Uta* and *Sceloporus* were captured two or more times during the same summer and found to have remained within a few feet or yards of the original point of capture. The data gathered during the summers of 1960 and 1961 were generally confirmed by the report of Tinkle *et. al.* published in early 1962. Because of the similarity between our data and that of Tinkle only the larger seasonal ranges were plotted on the map. However, by 1962 it became evident that *Uta* of the Temple Mountain area were longer lived than those reported by Tinkle; thus the home range studies were continued. What seemed pertinent and obviously our primary concern was to determine if these lizards actually did remain in a limited area during their lifetime.

TABLE 8. *Uta stansburiana* subsp.. Two Catches.

Lizard No.	Sex	Growth in mm. Snout-vent Length	Days between Catches 1 and 2	Distance (in ft.) Traveled Between Catches
13-20	M	2.0	56	0
10	M	5.7	820	20
18-19	F	1.5	85	10
19	F	0.6	90	57
2-20	F	0.0	95	10
2-5	M	3.0	93	42
2-10	M	1.0	93	45
2-17	F	0.5	93	20
1-2	M	3.3	730	225
3-4	F	0.0	730	375
2-7	F	0.0	90	0
9	M	2.9	60	254
10-13-14	M	0.0	20	45
9-10	M	0.0	19	30
3-15	M	2.0	90	90
3-6	M	1.0	90	45
3-8	M	0.5	90	60
3-17-18-19	M	1.0	90	102
4-19	M	2.5	90	0
5-20	F	0.0	90	30
1-2-6	F	0.0	45	24
8-10-15	M	2.0	630	300

Data gathered in 1962 and 1963 did not alter our conclusions based on seasonal distribution but did indicate that those lizards caught in two or more seasons(summers) had, with few exceptions, increased the size of their home range. This increase in range during two seasons is explainable on the basis of a new home range each season. Thus the lizard apparently establishes a new home range each spring as hibernation ends. Since the lizard is in the same general area at emergence in the spring, the second or third ranges tend to overlap in part at least or to be adjacent to the one of the previous year. Unfortunately this point did not become obvious until the toe-clipped specimens were collected as the field work was being terminated. This is seemingly the only logical explanation which will account for the increase in *Uta* home range.

Our data dealing with longevity in *Uta* does not agree with that recently published by Tinkle, McGregar and Dana (1962). We have a number of recapture records of this species marked in 1960 and recaptured during the summers of 1962 and 1963 (See Table 8). This is confirmed by data gathered by Tanner and Jorgensen (1963) at the Nevada Test Site in which the longevity records are approximately parallel to those reported in this study. The three areas of study in Nevada, Utah and Texas are different in eleva-

TABLE 9. *Uta stansburiana* subsp., Three Catches

Lizard No.	Sex	Growth in mm. Snout-vent Length	Days between Catches 1 and 3	Distance (in ft.) Traveled Between Catches
3-6	F	1.0	380	90
16-18	M	6.0	371	138
5-11	M	0.0	456	54
6-9	M	0.0	710	111
8-15	F	0.0	319	90
4-14	M	0.0	405	275
7-13	M	0.0	45	210
20	F	1.5	90	18
19	F	1.6	738	75
1-7	F	1.0	100	190
17	M	0.0	720	171
2-7	F	0.0	99	54
2-4	M	0.0	35	150
10-14	M	13.0	628	125
4-5	M	1.0	724	30
3-17-18-19	M	2.0	354	102

Table 10. *Sceloporus undulatus elongatus*, Two and Three Catches

Toe No.	Sex	Growth in mm. S-V Length	Days Between Catches	Distance (ft.) Between Catches
4X	M	8.0	78	174
1X	F	2.5	360	165
19X	M	2.0	270	105
20X	M	0.0	330	105
7-15X	F	8.0	303	135
7-11X	M	5.0	332	141
8X	F		105	60
1-13X	F		33	109
4-5X	F		384	150
4-12X	F		22	20
6-8X	M		1	0
7-16X	F		25	10

tion as well as latitude. It must certainly be true that *Uta* in Texas have at least three, perhaps more, months a year in which to be active over what is commonly the case in Utah. At the Nevada Test Site the yearly activity of *Uta* appears to be intermediate between the study sites in Texas and Utah. This range of activity also may have contributed to such variations in longevity as are now appearing in our data.

According to Tanner and Jorgensen (1963) the *Uta* found at the Nevada Test Site belong to the subspecies *stansburiana*, the same as those populations from central Utah, and are not *stejnegeri* as reported by Stebbins (1954). If the Nevada and Utah populations belong to the subspecies *stansburiana* and the Texas populations to *stejnegeri*, a genetical difference as well as climatic variables may be partly responsible for the reported longevity differences.

Following is a summary of our findings for this objective:

1. **Home Range.**—A. Both *Uta* and *Sceloporus* have limited home ranges. In both species studied the home ranges seemingly consist of a general area, including areas for hiding, shelter and perhaps basking (this is usually a ledge or exposed rock), surrounded by a feeding area. Home ranges vary in size from those having a surface less than 500 square feet to those of several thousand square feet, with *Sceloporus* having the larger seasonal territories. Our data include home ranges established for one season and for those over a period of three summers. This added time appears to have a decided effect on the size of ranges, for it has been noted that these lizards do not move far during the course of one summer, but may alter their range as they emerge from hibernation. The extent of range alteration must yet be thoroughly investigated.

The population of *Cnemidophorus tigris* was not large on the Temple Mountain Mesa. Because of their size a few may be deceiving as to numbers. Twenty five were marked and five were recaptured. In all cases those recaptured were not far from the original point of capture. The few data available from this study are similar to studies presented on this subject by Fitch (1958); Jorgensen and Tanner (1963); and Bellis (1964). An attempt to find marked lizards 100 to 200 feet beyond the boundary of the plot area was negative for all three species marked.

The size of home ranges indicates that the three species of lizards studied at Temple Mountain remained in the area and would therefore be subjected to a rather uniform radiation.

B. Female *Uta* do not have as large a home range as do the males. It is also common to find several females in close association; however, males do not seem to show this association even after the mating season. During April and May our observations indicate that *Uta* are nearly always found in pairs. Whether or not this species is strictly monogamous is not yet established. However, we have not found the home ranges of males overlapping, but males and female, and female ranges do overlap.

C. There is little evidence thus far that *Uta* or *Sceloporus* change locations during a summer season. Once they have established a territory, it is not readily abandoned. If, however, the lizard is removed from its range or, as in a few cases, has its shelter destroyed, males will move for rather long distances. While we were catching gravid females in 1963, 40 males were marked by placing a white paint mark on their heads. They were then released at a central location over one hundred yards or more from their home ranges. These males very rapidly dispersed and a few days later several were seen between two and three hundred yards from the point of release. In all cases they had moved downhill from the point of release.

2. **Longevity.** We have several records which indicate that some *Uta* live for at least three years. These records were first made in 1960, at which time over a hundred *Uta* were marked by toe clipping. Six of these were recaptured in June of 1962. A continuation of these records through the summer of 1963 repeatedly demonstrated that in this species longevity is not annual as indicated by Tinkle *et. al.* (1962), but

may in some individuals include at least two and perhaps three breeding seasons and include at least three to four years of life.

In 1961 the opportunity came to make similar tests at the Nevada Test Site, near Mercury, Nye County, Nevada. Under the supervision of D. M. Allred and the direction of Clive D. Jorgensen plots were established for the purpose of testing home range, growth and longevity. The latter was demonstrated to be at least three years for *Uta* in the populations of southern Nevada (Tanner and Jorgensen, 1963).

The three locations where these studies have been made (western Texas, southern Nevada and southeastern Utah) all vary as to elevation, yearly temperature ranges, yearly and perhaps also seasonal precipitation and other basic ecological factors. However, they are all in desert areas with sparse vegetation and much exposed surface of either sand or rocky surface areas.

A general consideration of the elevation may have the greatest effects on the longevity, since a decrease to less than 2,000 ft. elevation increases the general range of temperatures; although this may, and undoubtedly does, make for higher temperature during the summers in Texas, it also extends the activity range for *Uta* to ten or more months and for mild winters some activity throughout the year. The Temple Mountain area is approximately 5500 feet in elevation and several hundred miles north of either the Texas or southern Nevada study areas. At this elevation and north latitude *Uta* are forced to hibernate for at least three and usually for four or five months. Some activity may occur in March and October; however, in general only six months (April through September) provide climatic conditions suited to full lizard activity.

The effect of such climatic conditions in Utah is to extend the reproductive cycle into the summer rather than the spring months. Eggs are laid in late June and July. Most hatchlings appear in August. Thus only two, or possibly 2½ months, remain for growth before hibernation. This requires additional growth after hibernation and provides for a mixed population of adults and juveniles during the spring breeding season. It is not until June that the population has reached a nearly uniform adult status.

Our observations indicate that mating occurs in April and May, much too early for juveniles to have reached sexual maturity. Our limited data in this area indicate that *Uta* do not mate until the second spring and may then live for at least one additional reproductive cycle; perhaps some individuals live for a total of three.

An example is found in Table 1, Specimen No. 10, a male toe-clipped on June 9, 1960, and measuring 43.3 mm., recaptured on September 2, 1962, nearly 27 months later, at which time it measured 49 mm., a growth of 5.7 mm. This lizard was a young adult, hatched in late July or August of 1959 and having been extant for at least 37 months when last seen in September of 1962. According to our field notes this lizard was active and in apparent good health when last seen.

3. **Growth.** A summary of the field data dealing with growth and age in *Uta* is presented in Table 6. A comparison of these general data to those of Tanner and Jorgensen (1963) for the Nevada test site are surprisingly similar and reveal that there is little ecological difference between the population in east central Utah and southern Nevada.

Uta are the most abundant lizard in the areas studied. Although no attempt was made to determine density of any species population, there appeared to be little difference in general abundance between the Temple Mountain, Utah and Nevada Test Site populations of *Uta*.

There is undoubtedly some competition between the three species here considered. *Sceloporus* and *Cnemidophorus* are both larger than *Uta* and may feed on larger insects, thus reducing their competition with *Uta*. *Sceloporus*

TABLE 11. Size and Approximate Growth Rates for *Uta stansburiana* Summarized from Data Compiled over a Period of Four Years at Temple Mountain, Emery County, Utah.

Date	Age Group	Snout-Vent Length
Late July and August	Hatchlings as they emerge from eggs	21-25 mm.
Late August	Hatchlings approximately one month old	25-30 mm.
Middle to Late September	Juveniles six weeks to two months old	31-35 mm.
March and April	Juveniles emerging from hibernation	36-39 mm.
May	Subadults reaching adult size but not showing the nuptial color	38-41 mm.
June	Subadults or adults	42-45 mm.
July	Adults	44-47 mm.
2nd Year	Adults	45-51 mm.

inhabits the rocky sidehills and ledges, whereas *Cnemidophorus* is in the depressions and along gullies where there are fewer rocks and open spaces of sand and eroded soil. Thus the size of food items taken and the ecological niche inhabited by these species reduces the competition for food and space.

Because these three species live together—at least *Uta* is found throughout the ranges of the larger species—it was suspected that the larger species may prey upon the smaller *Uta*. To determine this a thin metal sheet fence of about 2½ feet high was set up in the Temple Mountain area, and a known number of individuals of each species was placed inside. The fence surrounded several small brush and an open sandy area. Rocks were placed in a loose pile for added shelter. For nearly a month the lizards were fed insects gathered from an alfalfa field some miles away. The insects varied in size and kind and were readily taken by the *Uta* and *Sceloporus*. *Cnemidophorus* was shy at first and one refused to eat. By controlled feeding we could be assured that the larger lizards were hungry, yet neither of the larger lizards preyed on the *Uta*.

Objective No. 3—The third objective was to establish the amount of radiation in the various areas under consideration.

The ground surface radiation count of gamma and beta rays was made at various times since June 1, 1960. Tests were made at Temple Mountain, three miles west of Temple Mountain, and at Mamie Stover during August 1960. In September 1961 tests were made at Yellow Cat and in May 1962 Indian Creek was tested and rechecks were made at the other areas. In order that all radiation measurements would be figured the same, all tests were made by Dr. A. Lester Allen and me. Table 12 provides the available data.

Objective No. 4.—The fourth objective was to determine the degree of external morphological variation existing in populations inhabiting areas of natural radiation and to compare these with each other and with populations occurring in nearby areas having a lower surface radiation.

The data presented in the following graphs have been taken from those external characteristics for which a more exact statistical analysis could be made. Therefore, scale counts in lizards are used for the graphs and a discussion of color and color pattern is provided for the lizards and small mammals.

Measurements were taken for all species examined. These data are, however, dependent on such variables as age and available food and thus were not included as graphed data. An analysis of growth and size is provided for *Uta* and *Cnemidophorus* in the Nevada Test Site study by Tanner and Jorgensen (1963). These data correspond closely to that observed in this study. Although growth and size were not major considerations, some information has been included in previous discussions or will be included in subsequent discussions under each species.

Before considering the variations in lizards, it should be emphasized that in the areas studied only a few snakes (four *Crotalus* and two *Masticophis*) were seen during the four years of field work. Thus adequate data for such a study are available only for the lizards.

An examination of reptiles in general and Sauria in particular shows that these as a group have scale patterns which are used as standard characteristics in determining their classification. I have used six of these scale counts in gathering the variation data: dorsal scales, from parietal to base of tail; ventral scales, beginning with enlarged scales at or near anterior margins of front legs to the last enlarged scales anterior

Table 12. Radiological Survey (mr/hrs). Units: X background (11 mr/hr. at Provo, Utah)

Test Area Location	Generalized Area		Specific Pockets	
	Gamma only	Gamma and Beta	Gamma only	Gamma and Beta
Temple Mountain	1.5-3.5x	Not Measured	Up to 3.5x	Not measured
3 miles West of Temple Mountain	1.5-1.8x	Not measured	No increase over general area	Not measured
Mamie Stover	1.6-5.5x	1.5x	Up to 100x	Up to 1000x
Yellow Cat	1.5-2x	1-5x	Up to 25x	Up to 500x
Indian Creek	1.5-2x	1-10x	Up to 12x	Up to 500x

Note: Utah Valley background radiation increased 2.5x (gamma) to 8x (gamma and beta) during the late spring of 1962 because of the nuclear tests just prior to that time. This increase was found elsewhere in the west perimeter, proportional to the rainfall. None of the test areas had any noticeable increase, which may be attributed to the relatively small amount of precipitation in those areas since the Russian and United States tests in 1961 and 1962.

to vent, scale rows around midbody, total femoral pores, supralabials, counting each side separately; and infralabials, counting each side separately. These characteristics are graphed for each species and for each population.

The Upper Colorado River Basin of Utah and the adjoining states to the south and east is a vast area of distribution for these lizards, and there are undoubtedly clinal variations which provide for variation among the populations. In order to remove as much clinal variation as possible the areas of study were selected within a radius of fifty miles and in areas of similar ecology. In fact, the lizards taken in the areas of high surface radiation inhabit the same rock formations in the study areas, thus providing as nearly as possible a similar physical and biological environment. Except for the Mamie Stover area there is also a close similarity in the radiation factor.

Each area and each species has been given a code number. For *Uta* the code number is A; *Sceloporus*, B; and *Cnemidophorus*, C. The areas are coded as 01, 02, 03, etc. Table 13 will provide the code information for all graphs, species and areas.

Each graph provides the following information: the area, such as A-01; the range of variation, indicated by the long horizontal line; and the mean by the vertical line above the range.

TABLE 13. Area Code Numbers for *Uta stansburiana**

A-01	Temple Mountain Mesa
A-02	Lower Temple Mountain Range
A-03	Upper Temple Mountain Range
A-04	Mamie Stover
A-05	Yellow Cat
A-06	Indian Creek

*For *Sceloporus* substitute B and for *Cnemidophorus* C.

The rectangle encloses one standard error of the mean and the horizontal line above the mean represents one standard deviation on each side of the mean. The figures on the left margin of the horizontal lines are the number of specimens included in the calculations for each area studied.

For each of the six areas three species of lizard were studied, and for each species six characteristics were considered in the analysis. Each characteristic is graphed for each population, thus providing 18 graphs.

The six graphs prepared for each species (*Uta stansburiana*, *Sceloporus undulatus* and *Cnemidophorus tigris*) will be briefly discussed as each species is considered. A general consideration of variation, as it pertains to the lizards and small mammals, will then summarize the results of the project.

LIZARD SPECIES STUDIED

Uta stansburiana stansburiana Baird and Girard

The Northern side-blotched lizard inhabits most biotic communities in the Upper Colorado River Basin from the low river valleys up to the Juniper-Pinyon pine forests. In this general area *Uta* is the most abundant of the lizard species and is more commonly seen in the brushy habitat than on the ledges or rocky talus slopes.

Our field records indicate that of the three lizards studied *Uta* is the most active. That is, individuals leave hibernation earlier in the spring and seek it later in the fall. During the summer or months of activity, *Uta* is the first to leave shelter in the morning and the last to seek it at evening. The availability of *Uta* for study, not only its abundance in the study areas but also its wide range of activity, has permitted me to use larger series in all characteristics analyzed.

Figures 7, 8, 9, 10, 11 and 12 provide the data for the six external morphological characteristics used in the analyses of *Uta*. Each one will be briefly reviewed. As indicated in Table 12, the area coded as A-01, A-04, A-05 and A-06 were the study areas with a higher surface radiation. The other two were adjoining A-01 and had a lower surface radiation. Hereafter only the code numbers will be referred to rather than a repeating of localities.

Results: 1. The scale rows as analyzed in Figure 7 do not provide significant differences in the variations between the populations studied. Areas A-04 and A-05 are the most divergent, yet in both of these populations the standard deviation of their means is overlapping one another.

Equally significant is the lack of variation between area A-01 and the adjoining areas of A-02 and A-03.

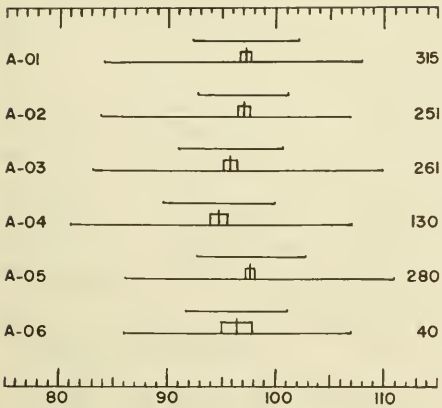


Fig. 7. Number of scale rows at midbody in six populations of *Uta stansburiana*. The range of variation is indicated by the horizontal line, the mean by the vertical line, the rectangle encloses one standard error on each side of the mean and the shorter horizontal line above the vertical line (mean) represents one standard deviation of the mean. The number of scales (rows) is indicated both at the bottom and the top of the graph, with the populations (areas A-01) to the left of the range (long horizontal line) and size of the population sample on the right margin of the range.

2. The number of scales in the dorsal series (Fig. 8) is noticeably more variable than the number of scale rows (Fig. 7). A skewing to the right of the populations A-04, -05 and -06 in this character is obvious. Again the areas A-01, -02 and -03 are similar. The greatest variation between these populations occurs between A-02 and A-05. In these there is a difference of 6 scales between the means; and although the standard deviations overlap, this is less than 50 percent.

3. The numbers of ventral scales as graphed in Figure 9 show little variation.

4. Figure 10, representing the total number of femoral pores, provides a different pattern of variation. In the first four populations there is a decrease in the mean from A-01 to A-04. The means of A-05 and A-06 are noticeably skewed to the left, yet as graphed the means vary only approximately three pores and the standard deviations of all populations overlap.

5. Variation of the supralabials in these populations is nil. The variation between the means is less than one scale (Fig. 11).

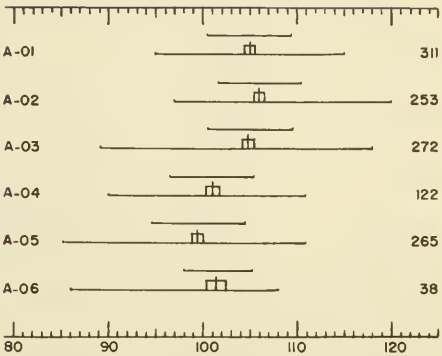


Fig. 8. Dorsal scale in *Uta stansburiana* counting from parietal to base of tail. See Fig. 7 for explanation of graph.

6. The infralabials (Fig. 12) in contrast to the supralabials are more variable. Extreme variation between the means is approximately 1.2 scales. This is in contrast to a mean variation in the supralabials of approximately 0.3 scales. A total range of variation in the supralabials is 6 and for the infralabials 5 scales. A variation of more than 1 scale in a character with so small a range of variation seems noteworthy, yet the standard deviations of all populations overlap.

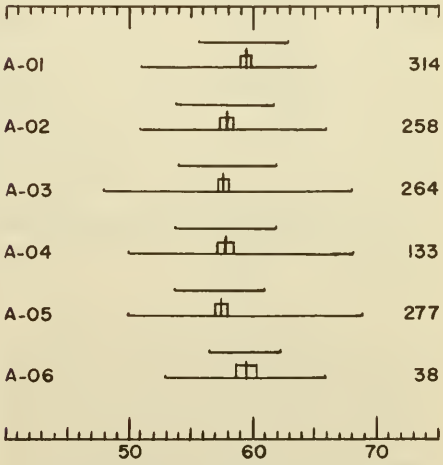


Fig. 9. Ventral scales in *Uta stansburiana* counting from the enlarged scales just posterior to the gular fold (this is approximately at the anterior square of the front legs) to the granule scales at the vent. See Fig. 7 for explanation of the graph.

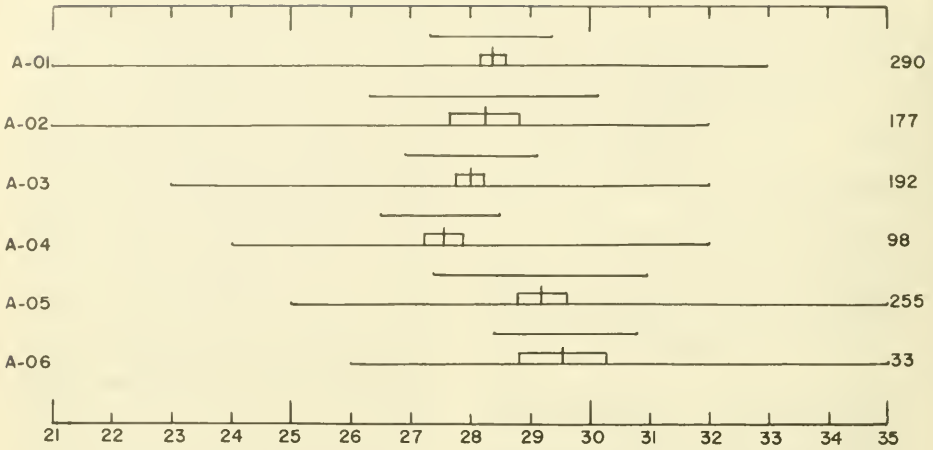


FIG. 10. Total number of femoral pores on both femurs in *Uta stansburiana*. See Fig. 7 for explanation of graph.

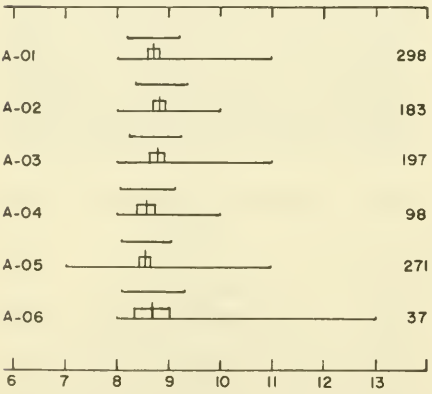


FIG. 11. Total number of supralabial scales on both lower lips in *Uta stansburiana*. See Fig. 7 for explanation of graph.

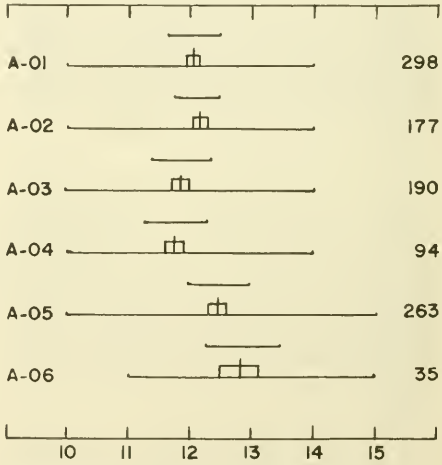


FIG. 12. Total number of infralabial scales on both lower lips in *Uta stansburiana*. See Fig. 7 for explanation of graph.

Sceloporus undulatus elongatus Stejneger

The Northern Plateau Lizard inhabits the rocky boulder-strewn sidehills and the ledgy outcroppings within its range. It is found in northwestern New Mexico, northeastern Arizona, western Colorado and all of the Upper Colorado Basin of Utah extending as far north in the Green River Valley as southern Wyoming.

For this species the same general procedures will be followed as for *Uta*. The graphed data for *Sceloporus* are found in Figures 13 to 18, and the scale characteristics will follow in the same sequence as was used in considering *Uta*.

The reduced numbers of individuals reported in the *Sceloporus* populations samples represent all the individuals we could secure, and are not small samples by choice. The population at B-04 was originally small, and after several collecting trips the first year (1960), the population was depleted.

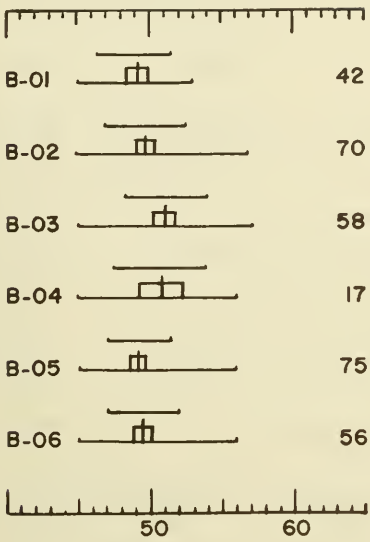


Fig. 13. Number of scale rows at midbody in *Sceloporus undulatus elongatus*. See Fig. 7 for explanation.

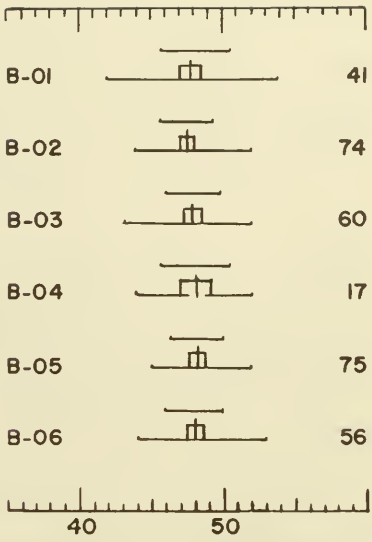


Fig. 14. Dorsal scale in *Sceloporus undulatus elongatus*, counting from parietal to base of tail. See Fig. 7 for explanation of graph.

Results: 1. The scale rows around the body vary little in these populations. An extreme variation of only 2 scales exists between the population means. Perhaps the most interesting factor in this character is the narrow range of variation (8 scales) in the B-01 population.

2. The dorsal scale series is very uniform, with the variation between any two population means being less than 1 scale. In contrast to the scale rows around the body the population B-01 has the greatest range of variation (12 scales), and population B-04 the least with only 7.

3. There is more variation in the ventral scale rows than in either of the preceding characters. In both the total range (9 to 16 scales) and in the population means (2 scales) there are greater variations. In this character, in spite of the larger number of individuals the population B-05 has the least variation, and B-01 is larger than any other by 3 scales.

In this character as in the two preceding characters there is considerable overlapping of the standard deviations.

4. The total number of femoral pores ranges from 30 to 47 pores; however, the means for the populations vary only approximately 2 scales. This is not a great variation as is indicated by

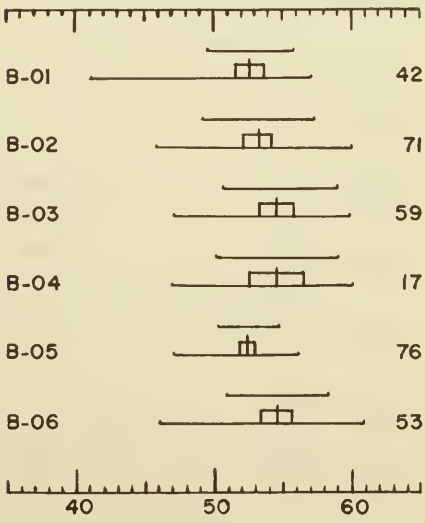


Fig. 15. Ventral scales in *Sceloporus undulatus elongatus* counting from the enlarged scales just posterior to the gular fold (this is approximately at the anterior square of the front legs) to the granule scales at the vent. See. Fig. 7 for explanation of the graph.

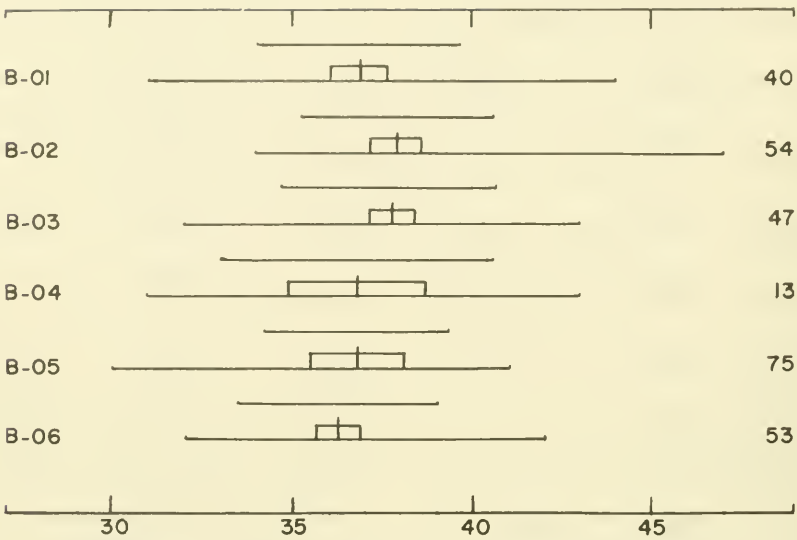


FIG. 16. Total number of femoral pores on both femurs in *Sceloporus undulatus elongatus*. See Fig. 7 for explanation of graph.

the almost complete overlapping of the standard deviations.

5. There is little variation in the supralabials. The population means are all between scales 8 and 9, and the standard deviations are also basically in this same range. Noticeably distinct from all other graphed data for this species

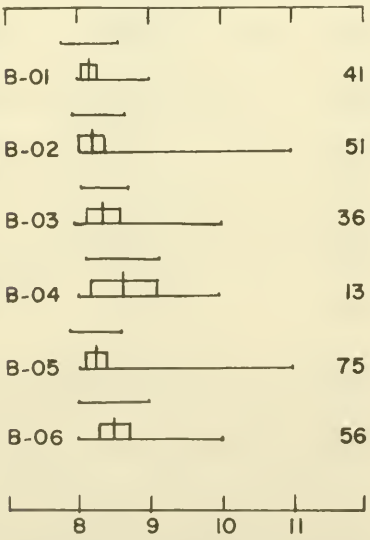


FIG. 17. Total number of supralabial scales on both upper lips in *Sceloporus undulatus elongatus*. See Fig. 7 for explanation of graph.

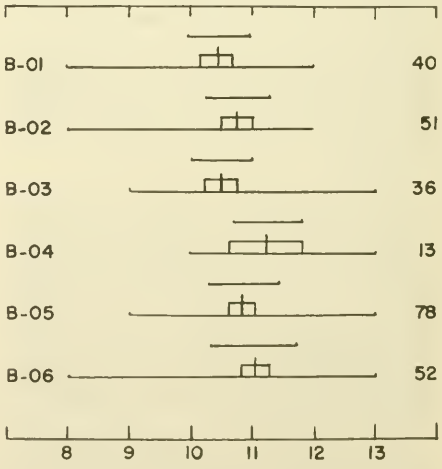


FIG. 18. Total number of infralabials scales on both lower lips in *Sceloporus undulatus elongatus*. See Fig. 7 for explanation of graph.

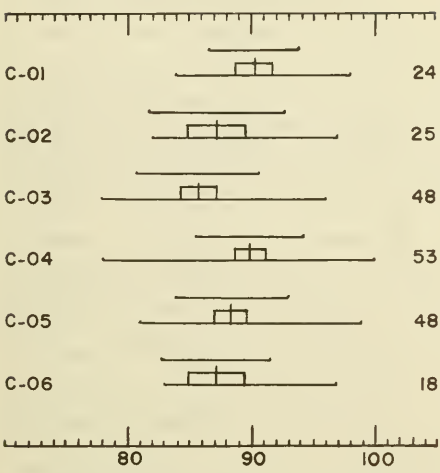


Fig. 19. Number of scale rows at midbody in six populations of *Cnemidophorus tigris septentrionalis*. See Fig. 7 for explanation of graph.

is the extreme skewness to the right of the means and standard deviations for all populations. In those populations with the greatest range of variation (4 scales, 8 to 11) the skewness is greatest. This emphasizes the regular occurrence of 8 scales in all populations.

6. In the infralabials there is a greater range of variation, 6 scales, but much less skewness. Populations B-01, B-02 and B-06 are skewed to the left, whereas the others are slightly skewed to the right. The variation between the population means is less than 1 scale, and the standard deviations of all populations overlap.

Cnemidophorus tigris septentrionalis Burger

The northern whiptail is the largest and fastest of the common lizards found in the general study area. It is more commonly found along the washes but forages along ledges and among the larger shrubs and juniper trees. This species does not climb on the ledges as is commonly done by *Sceloporus* and occasionally by *Uta*, but remains on the ground. It may find shelter under ledges or large rocks, but is seemingly more at home in rodent holes under the branches of a shrub or a hole under or along the side of a rock.

As in the case of *Sceloporus*, the whiptails are not as abundant as *Uta* and were practically eliminated from the study areas as we secured the series of specimens.

Those graphs with the data for *Cnemidophorus* are found in Figures 19 to 24. The same

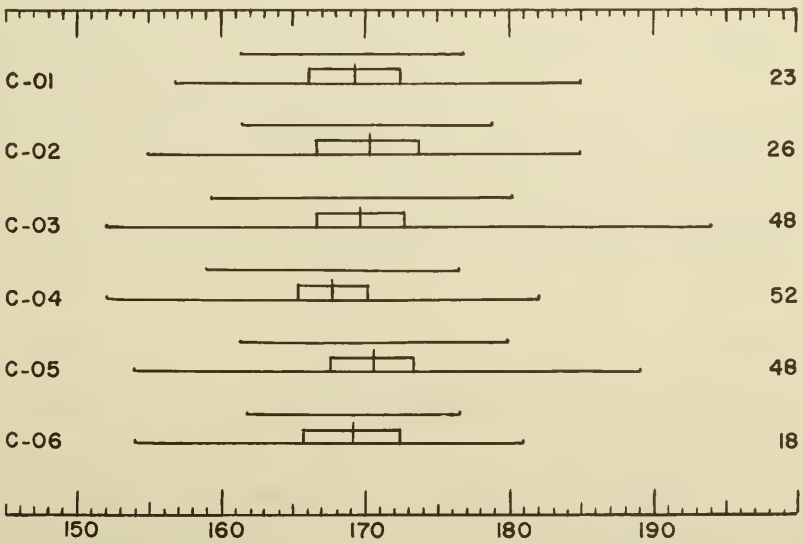


Fig. 20. Dorsal scales in *Cnemidophorus tigris septentrionalis*, counting from parietal to base of tail. See Fig. 7 for explanation of graph.

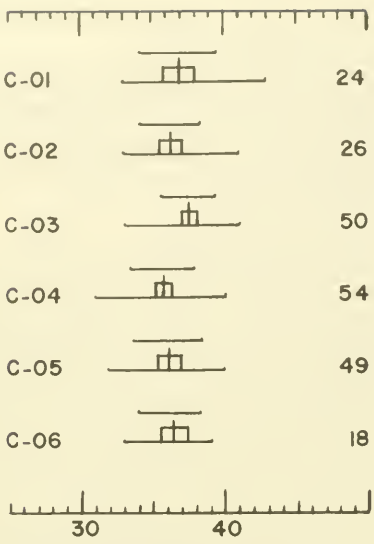


FIG. 21. Ventral scales in *Cnemidophorus tigris septentrionalis*, counting from the enlarged scales just posterior to the gular fold (this is approximately at the anterior square of the front legs) to the granule scales at the vent. See Fig. 7 for explanation of the graph.

characteristics presented in the same sequence as in the two preceding species will be given for this species.

1. There is little variation in the range of the scale rows. The greatest range of 22 rows is found in population C-04 and least of 14 rows in C-01 and C-06. An extreme of 4 rows (between C-03 and C-04) occurs in the population means; however, the standard deviations for all populations are not significantly variable.

2. There is little variation in number of scales in the dorsal rows. In this characteristic the extremes of the range of variation is 41 scales, and although this extreme is not reached by all populations, the minimums is 27 scales. It is noteworthy that the means for these populations vary less than 3 scales.

3. The number of scales in the ventral rows of these populations are remarkably uniform and show little variation. An extreme variation in the range of only 12 scales and of only approximately 2 scales in the population means is evidence of the sameness of these populations in this character.

4. The range of variation in the total number of pores is from 34 to 49, or 15 pores. The two population extremes are between C-03, with 34 to 48, and C-05, with 40 to 49. Population

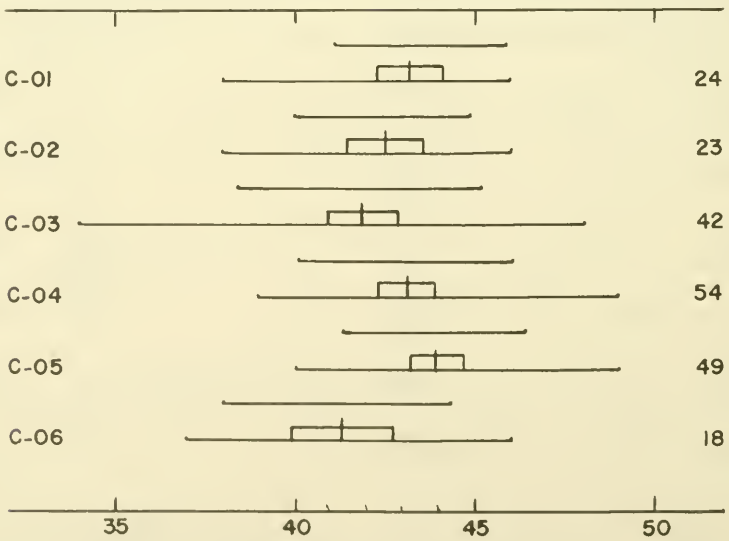


FIG. 22. Total number of femoral pores on both femurs in *Cnemidophorus tigris septentrionalis*. See Fig. 7 for explanation of graph.

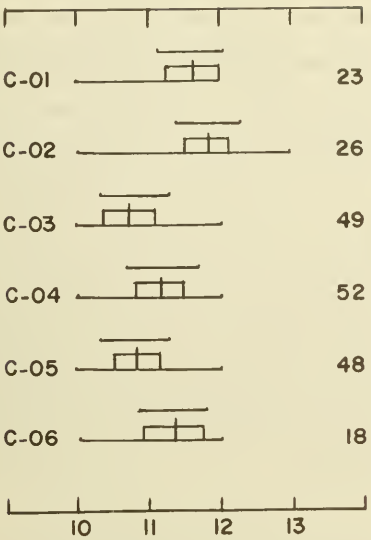


Fig. 23. Total number of supralabial scales on both upper lips in *Cnemidophorus tigris septentrionalis*. See Fig. 7 for explanation of graph.

means vary only 2.5 pores, and the standard deviations overlap widely.

5. Perhaps the most significant variations observed in this species occur in the supralabials. Although one might expect the extremes of variation to occur between those populations inhabiting the areas with high surface radiation, in this instance at least those two areas with lowest radiation (C-02 and C-03) have not only the greatest variation in range but also the greatest mean variation.

In a character such as this, with a total range of variation equaling only three scales, a population means which varies 1 scale is seemingly significant, not perhaps in this case to establish an important and significant population difference, but to indicate the separateness of populations in a given small area. Populations C-02 and C-03 occur in adjoining small tributary washes which are separated by a small ridge. The washes join about half a mile below the designated areas. Yet these populations in spite of their close approximations do not apparently interbreed. This is an added evidence of close territorialism in this species.

6. The infralabials show no more variation in the population means than occurred in the supralabials even though the total range is twice as great (6 scales). Figures 23 and 24 show a very similar pattern of variation but with more overlapping of the standard deviations in the infralabials.

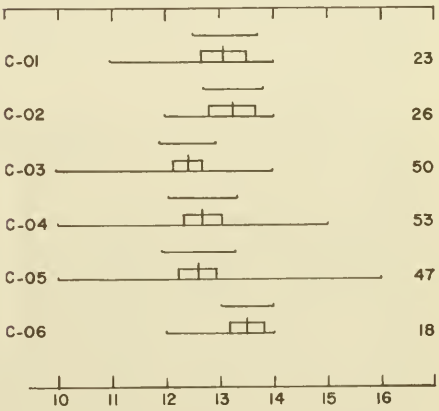


Fig. 24. Total number of infralabials scales on both lower lips in *Cnemidophorus tigris septentrionalis*. See Fig. 7 for explanation of graph.

MAMMALS

Five species of small mammals were found in each of the study areas. Several other species were taken in limited numbers in some of the areas, thus not providing enough specimens for adequate comparative purposes. Table 4 lists the species taken at each area and the specimens now available at the Brigham Young University Museum. Species with at least four adult specimens from an area have been carefully compared as to their pelage and color variations.

In making a preliminary comparison of the allopatric species, several variations are notice-

able. The squirrels provide a variation in the color of the pelage. Those taken at Temple Mountain show greater variation within the series and are not like the series from either Yellow Cat or those taken thirty miles to the north along the San Rafael Reef in the Mamie Stover area. This is not as we had expected. In fact, other series, *Neotoma lepida sanrafaeli* and *Peromyscus crinitus dontti*, show similar population variations. Based on the nearness of the Temple Mountain and the Mamie Stover areas, and the complete lack of barriers, one would expect greater similarities between these populations than between those occurring across the Green River in the Yellow Cat district. However, only in the chipmunk and white footed deer mouse do we find a close similarity between the two San Rafael populations. In the mammals, as is evident in the reptiles, relatively minor barriers seemingly have served to provide for population and subspecies variations, or other environmental factors operating in conjunction with the barriers are responsible for the pelage variations.

Ammospermophilus leucurus notum

The antelope ground squirrel occurring in the three areas in which mammals were studied represents two subspecies, *notum* in Emery County and *pennipes* in Grand County. The populations indicate a very definite pelage variation, particularly between the Yellow Cat and the Temple Mountain populations. In the Yellow Cat population and dorsal-lateral line stripes are usually straight or with only a slight curve, whereas in the Temple Mountain series the stripes are noticeably curved, often providing for two undulations. The basic pelage color in the Temple Mountain population is lighter, with a more buff-reddish color. Furthermore, there is considerably more variation in the series, extending from dark brownish-gray to a light reddish buff. The lack of variation between individuals of the Yellow Cat population is most striking when compared with the Temple Mountain series. The Mamie Stover area is represented by only two specimens, both of which are very similar to those taken at Yellow Cat. They do not exhibit the basic pelage or pattern characteristic of the Temple Mountain series in spite of the fact that they inhabit a very similar habitat.

Eutamias quadrivittatus hopiensis

The chipmunks of the area offer a better example for comparative variation studies since, according to our present understanding, they belong to a single subspecies. However, it is very obvious that the Temple Mountain-Mamie Stover series represent a single population, whereas those from Yellow Cat represent a second distinct population. The latter exhibits a distinct pelage pattern in which the four stripes stand out sharply in contrast to the reddish ground color. In contrast, those taken at Temple Mountain and Mamie Stover show less distinctness, with both the stripes and the reddish ground color appearing washed out or faded. This is reflected also in the tail and particularly in the ventral-lateral region, which in some of the Emery County population has faded to a yellowish buff rather than retaining the reddish ground color. In the chipmunks a distinct pelage variation occurs between those populations sampled in the San Rafael populations and the Yellow Cat population. There is seemingly a different gene pool than that occurring in the Yellow Cat population.

Neotoma lepida saurafaeli

The common packrats provide a similar presumably anomalous phenomenon in which the pelage color and the basic variations in the Mamie Stover population are duplicated by the series from Yellow Cat, whereas the population from Temple Mountain is relatively uniform in color and distinct when compared with the other populations. The pattern of the Temple Mountain series has a greater amount of yellow, particularly laterally, but blending into the brownish-grey dorsal pelage and giving a more yellowish, almost buff, color. In *N. lepida*, as in *A. leucurus* discussed above, a similar population variation relation exists; that is, the Yellow Cat-Mamie Stover series seem to represent or approximate the same variations within each population.

Peromyscus maniculatus sonoriensis

The deer mouse from the Temple Mountain area represents a population with considerable pelage variation, ranging from slate to gray to yellowish-buff, with several gradations in between these extremes. The range of variation is striking, particularly when contrasted with such uniform color patterns as are found in *Neotoma lepida* and *Eutamias*. The remarkable factor in this species is its absence from the trapping areas at Mamie Stover.

Peromyscus maniculatus nebrascensis

The *maniculatus* population at Yellow Cat represents the subspecies *nebrascensis*. This sub-

species provides a number of interesting variations ranging from a dull slate gray to a rich buffy brown. Specimens representing the extremes in pelage color are adults, and both were taken within a day of each other in 1962. Even though we cannot compare directly the *maniculatus* because of the different subspecies, the variation within the population is obvious and marked.

Peromyscus crinitus

The *crinitus* deer mouse occurring in the areas trapped consists of two subspecies, *doutti* in the Emery County areas and *auripectus* at Yellow Cat. The latter is a dark brownish-gray pelage with some buffy colors, principally on the dorsal and lateral parts of the body and snout regions, whereas the subspecies *doutti* is much lighter, with yellowish-buff pelage nearly uniform over the body and head. The series from Temple Mountain is noticeably lighter than is the one from Mamie Stover, although it is obvious that these two populations are actually not at as great a variance with each other as are the individual members of *Peromyscus maniculatus sonariensis* from Temple Mountain.

The Kangaroo rats, *Dipodomys ordii*, occur in the Temple Mountain and Yellow Cat areas, but represent two subspecies. Only a few specimens are available for comparison, and these show a distinctly lighter pelage pattern for the Temple Mountain material corresponding very closely to a few specimens taken at Green Water Spring in San Juan County. A few other species are present in the areas, such as *Neotoma cinerea* and *Peromyscus truei*, but not in sufficient numbers to provide for reliable variation data.

A study in variation based on pelage pattern and color is neither satisfactory nor satisfying. The lack of small mammals at Mamie Stover and the crash of the population at Temple Mountain limited the numbers and this greatly affected the securing of adequate data for the mammals. Also the apparent similarities between some species in the Yellow Cat and Mamie Stover populations would require much more sampling of intermediate populations to permit any conclusions.

Although several obvious variations have been found between these mammal populations, indicating a definite difference in the gene pool of several species, the cause of these variations is not at all obvious. One is not, on the basis of the data available, able to suggest that the variations occurring in these populations is not due to normal individual variation induced by those factors in nature responsible for induction of variation in most populations and maintained in the population by limited geographical or ecological isolation. Data now available from the study areas, particularly the limited amount from the San Rafael populations, indicate that most species are variable and that these variations represent, as in the squirrel *A. leucurus* and the packrat *N. lepida*, a noticeable and pronounced variation. Unfortunately these variables cannot be subjected to statistical analyses, and there is therefore no satisfactory test for these external characteristics.

STATISTICAL ANALYSES OF THE DATA

In attempting to test the effects of surface radiation on the external characteristics of small vertebrates, I have investigated the general ecological factors in the immediate environment of the lizards and mammals and have measured the approximate soil mantle which covers the rocks bearing the radiation minerals. Insofar as possible the study areas selected were as similar in elevation, general climatic conditions, type and percent of plant cover, animal types and geological formations as one could obtain and at the same time include the areas of high surface radiation. An attempt was also made to keep the study areas on approximately the same southeast slope.

In spite of all such attempts and the relative nearness of the study areas, some physical and perhaps biological differences, even though small, still exist. The statistical tests indicate that these differences did exist in the areas tested (see Table 14). The extent to which these physical and biological differences created or influenced the variations cannot be separated. The predominance of the similarities, however, is considered to be of great importance and to provide as much ecological uniformity as can be expected in such a study program. It is therefore assumed that if the data indicate substantial variations in some of the characteristics studied, radiation may be, in part at least, respon-

TABLE 14. The analysis of variance (test's means) between high and low exposure groups and areas within exposure.

	A			B			C		
	Exposure	Areas	Error	Exposure	Areas	Error	Exposure	Areas	Error
Scale Rows									
D.F.	1	4	1271	1	4	312	1	4	210
M.S.	97.2500	235.8125	10.533	78.5703	22.1875	6.4937	398.5469	45.2227	21.4545
F	0.412	10.533		3.541	3.417		8.813	2.108	
Dorsals									
D.F.	1	4	1255	1	4	317	1	4	209
M.S.	3206.7500	1225.0000	20.2280	9.8047	2.0293	3.9776	38.8750	55.0781	81.9931
F	2.618	60.560		4.832	0.510		0.706	0.672	
Ventrals									
D.F.	1	4	1278	1	4	312	1	4	215
M.S.	191.3750	159.1406	14.6601	30.0391	63.6367	12.6603	40.6406	15.0879	4.6366
F	1.203	10.855		0.472	5.026		2.694	3.254	
Pores									
D.F.	1	4	1335	1	4	323	1	4	213
M.S.	77.1094	47.0703	3.5345	56.6289	4.3008	6.8780	61.9180	14.2344	7.3091
F	1.638	13.317		13.167	0.625		4.350	1.947	
S. Labials									
D.F.	1	4	1360	1	4	324	1	4	210
M.S.	6.2822	1.2175	0.7577	2.4045	1.5651	0.3543	7.6895	6.2736	0.7931
F	5.160	1.607		1.536	4.418		1.226	7.911	
I. Labials									
D.F.	1	4	1330	1	4	324	1	4	211
M.S.	19.0898	17.6113	0.6495	5.6943	4.6930	0.9293	6.0088	4.6301	1.3349
F	1.084	27.116		1.213	5.050		1.298	3.469	

sible. Therefore large samples of lizards from each study area were collected and the data provided in Figures 4 to and including Figure 21 were plotted. In order that the data are properly tested and all variations compared statistically for their variation significance, all data were submitted to Dr. Melvin W. Carter, Statistics Department, Brigham Young University, for perusal and testing.

Under Dr. Carter's direction the data were subjected to several tests, all intended to provide further evidence of the degree of significances inherent in the variations. In developing the following tests in which the variations in the areas of high and low exposure were tested, the variations associated with the lack of homogeneity of the test areas were taken into account.

1. The first F test is an analysis of variance with the study areas divided into high- and low-exposure groups and the areas within exposure are used as the error in testing the effect of exposure. This test, the ordinary F test used in the analysis of variance, determines whether or not the average (mean) of high exposure can be said to differ from the average (mean) of low exposure. Table 14 provides the test data.

2. The second F test partitions the sum of the square of the areas in the above analysis so that a measure of the variation in the means of the groups (areas) in high and low exposure can be compared. Thus an F test of the variation of means of high exposure over that of low exposure (divided by respective df) was used to test whether or not the variation in the means of the high exposure could be said to be greater than that of the low exposure.

The statistical formula used to compute the above F test is as follows:

$$F_{3,1} = \frac{HE(SS)/3}{LE(SS)/1}$$

where,

$$LE(SS) = n_1 (\bar{x}_1 - \bar{x}')^2 + n_2(\bar{x}_2 - \bar{x}')^2$$

$$HE(SS) = SS\ Areas - LE(SS)$$

$$\bar{x}' = \frac{n_1\bar{x}_1 + n_2\bar{x}_2}{n_1 + n_2}$$

The computed F values for the second test are listed for the three lizard species in Table 15.

It should be noted that there are no significant differences in the F values, as listed in

Table 15. An analysis of the variation in the means of the area group (high and low exposure), with a listing of the F values for each characteristic.

		Scale Rows		Dorsals		Ventrals		Pores		S. Labials		I. Labials	
Source	D.F.	M.S.	F	M.S.	F	M.S.	F	M.S.	F	M.S.	F.	M.S.	F
A													
H.E.	3	776.673	1.55	1577.245	9.37	209.887	30.41	62.428	62.18	1.361	1.73	20.133	2.01
L.E.	1	166.577		168.264		6.903		1.004		.787		10.035	
B													
H.E.	3	11.688	0.218	0.635	0.102	67.851	1.33	5.553	10.23	1.994	7.15	5.209	1.657
L.E.	1	53.687		6.212		50.995		0.543		0.279		3.143	
C													
H.E.	3	49.076	1.46	71.241	10.814	7.595	0.202	15.634	1.56	3.940	0.297	4.034	0.629
L.E.	1	33.662		6.588		37.568		10.025		13.274		6.407	

Table 15, for any of the characteristics tested.

3. This test (solid variance of high exposure different from pooled variance of low exposure) was devised to test whether or not the average variance of the groups with high exposure was different from that of those with low exposure. Table 16 provides the test data. The test used was the F test as follows:

This F test was a one-tail test since under the alternative hypotheses the high exposures were expected to have a larger variance on the average. Table 16 provides the test data. Note that the species are listed as A, B and C and the characteristics as 1 to 6 and in the same order as occurs in Table 15.

Table 16. Tests of the variance of high exposure compared with that of low exposure.

	F	dfd	df
A_1	1.11	510	761
B_1	0.728	126	186
C_1	0.892	71	139
A_2	1.14	523	732
B_2	1.29	132	185
C_2	0.741	72	137
A_3	0.838	520	758
B_3	0.562	128	184
C_3	1.35	74	141
A_4	0.978	542	793
B_4	0.976	134	189
C_4	0.856	72	141
A_5	0.845	558	802
B_5	1.39	137	187
C_5	1.25	73	137
A_6	1.08	549	781
B_6	1.12	136	188
C_6	1.24	74	137

4. The following and final F test was devised to test whether or not the heterogeneity (differences) of variances was different in low-exposure areas compared with high-exposure

$$F_{(\Sigma(n_i-1),\ \Sigma(n_j-1))} = \frac{\sum_{i=1}^{4} (n_i-1)\ S_i^2/\Sigma(n_i-1)}{\sum_{i=1}^{2} (n_j-1)\ S_j^2/\Sigma(n_j-1)}$$

areas. The null hypothesis was that this heterogeneity, if present, would be the same for both types of areas. The alternative hypothesis was that the differences in variances would be larger in the higher exposure than in the low exposures. The test devised is approximate. The procedure used here was to calculate a Bartlett's chi-square for each of the two type areas, high and low exposure; then an approximate F ratio was formed as follows:

$$F_{t3,1)} = \frac{\chi^2 H/3}{\chi^2 L/1}$$

None of these F ratios is significant at the .05 percent level. There was insufficient evidence to say that the variances of the high exposure differed more than the variances of the low exposure. Table 17 provides the data analyses for this test. It should be noted here that the test would not be sensitive to differences caused by exposure to radiation because of the small number of degrees of freedom in the F ratio. In this test it would have been better to have more groups in the study.

TABLE 17. The results of the approximate test, testing whether or not the lack of homogeneity of variance was greater in high exposure or low exposure.

Scale Rows		X_h^2	X_l^2	$F_{3,1}$	N_1	N_2	N_3	N_4	N_5	N_6
A_1	1	3.0237	7.5191	0.1340	315	251	261	130	280	40
B_1	2	5.7209	0.2836	6.7248	42	70	58	17	75	56
C_1	3	1.2448	0.3087	1.3440	24	25	48	53	48	18
Dorsals										
A_2	4	9.1301	0.1281	23.7512	311	253	272	122	265	38
B_2	5	4.2261	0.3555	3.9624	41	74	60	17	75	56
C_2	6	1.8337	0.5177	1.1806	23	26	48	52	48	18
Ventrals										
A_3	7	10.7015	1.7061	2.0908	314	258	264	133	277	38
B_3	8	25.6118	0.0466	183.3694	42	71	59	17	76	53
C_3	9	2.2078	0.5533	1.3300	24	26	50	54	49	18
Pores										
A_4	10	5.0569	0.1780	9.4717	322	263	281	132	302	41
B_4	11	11.4748	0.5617	6.8093	42	75	61	17	78	56
C_4	12	3.0224	1.5009	0.6712	24	26	48	54	49	18
S. Labials										
A_5	13	10.5368	0.1911	18.3768	322	270	290	134	310	40
B_5	14	28.5102	0.1852	51.3156	42	76	63	17	78	54
C_5	15	1.7658	5.4965	0.1071	23	26	49	52	48	18
I. Labials										
A_6	16	29.6565	32.7505	0.3018	321	268	283	130	297	37
B_6	17	4.6422	3.0460	0.5080	42	75	63	17	78	55
C_6	18	0.7661	0.0362	7.0532	23	26	50	53	47	18

CONCLUSIONS

Although the graphed data and the statistical analysis of these data show some significant variations, the great majority of the characteristics tested do not show, at the 95 percent level, significant variations between the populations in the areas of high and low exposure. We did find that the lizard populations in the different areas varied in some characteristics. These variations were significant. The differences between the population means of the same species are indicated by the larger figures in Table 14 in which the F values for the areas (A=*Uta*) are noticeably higher than the F values for exposure. Only in the I. Labials is the F value for exposure larger than the area value. In B (*Sceloporus*) and C (*Cnemidophorus*) characteristics there is closer F value between exposure and area in most characteristics; however in the case of dorsals and pores in *Sceloporus*, and scale rows and pores in *Cnemidophorus*, the F values for the exposure groups are noticeably higher. However, it should be pointed out that an analysis of the data provided by the F tests shows that the variations occur in areas with similar exposure and do not represent significant variation.

As indicated in Tables 14, 15 and 16, the differences in the high- and low-exposure areas did not vary more than in areas with similar exposure; therefore we had insufficient evidence (or data) to establish that the variations were caused by or resulted from exposure to radiation.

It is possible that other tests and additional data based on more areas or other areas and on additional characteristics (perhaps internal) may yet demonstrate that those areas with a higher surface radiation do produce in the small vertebrates inhabiting them a greater range of variation or other evidences of genetical change than occur in areas of lower surface radiation. However, in this study no significant variation is seemingly present—when the areas of higher surface radiation are compared with areas of low surface radiation—that would not be expected to occur in nature by chance alone.

Literature Cited

Bellis, Edward D. 1964. A Summer Six-lined Racerunner (*Cnemidophorus sexlineatus*) Population in South Carolina, Herpetologica, 20(1):9-16.

Boutwell, J. M. 1905. Vanadium and Uranium in Southeastern Utah, United States Geological Survey Bulletin, 260:202-210.

Brant, Daniel H. 1962. Measures of the movements and population densities of small rodents. Univ. Calif. Publ. in Zool., 62:105-184.

Burt, W. H. 1940. Territorial behavior and populations of some small mammals in southern Michigan. Misc. Publ. Mus. Zool., Univ. Michigan, 45:1-58.

Calhoun, John B. and James N. Casby. 1958. Calculations of home range and density of small mammals. U. S. Public Health Monograph. 55:1-24.

Cannon, Helen. 1952. The effect of uranium-vanadium deposits on the vegetation of the Colorado Plateau, American Journal of Science, 250:735-770.

Daniel and Blair. 1959. Background radiation and endemic faunal range in the San Luis valley of Southern Colorado. Great Basin Naturalist, 19(1): 37-42.

Durrant, Stephen D. 1952. Mammals of Utah. University of Kansas Publ., Mus. Nat. Hist., 6:1-549.

Fitch, H. S. 1951. A simplified type of funnel trap for reptiles. Herpetologica, 7:77-80.

———. 1960. Autecology of the Copperhead. University of Kansas Publ., 13(4):85-288.

Harrison, Bertrand F., Stanley L. Welsh, Glen Moore. 1964. Plants of Arches National Monument. Brigham Young University Sci. Bull., Biol Series, 5(1):5-23.

Hayward, C. Lynn, D Elden Beck, and Wilmer W. Tanner. 1958. Zoology of the Upper Colorado River Basin. The biotic communities. Brigham Young University Sci. Bull. Biol. Series, 1(3):1-74.

Hilpert, L. S. and M. D. Dasch. 1964. Mineral and water resources of Utah, Report of the U. S. Geological and Mineralogical Survey and the Utah Water and Power Board. Prepared at the request of Senator Frank E. Moss. U. S. Government Printing Office, Washington, 1964:1-275.

Jorgensen, C. D. and W. W. Tanner. 1963. The application of the density probability function to determine the home ranges of *Uta s. stansburiana* and *Cnemidophorus t. tigris*. Herpetologica, 19(2): 105-115.

Mohr, C. O. and W. A. Stumpf. 1964. Relation of tick and chigger infestations to home areas of California meadow mice. Jour. Med. Ent., 1:73-77.

Nelson, R. F. 1957. A preliminary investigation of the role of selenium in the growth of S. *pinnata*. B.Y.U. Master's Thesis—unpublished.

Sorensen, Don. 1963. Wonder mineral: Utah's Uranium. Utah History Quarterly, 31(3):280-290.

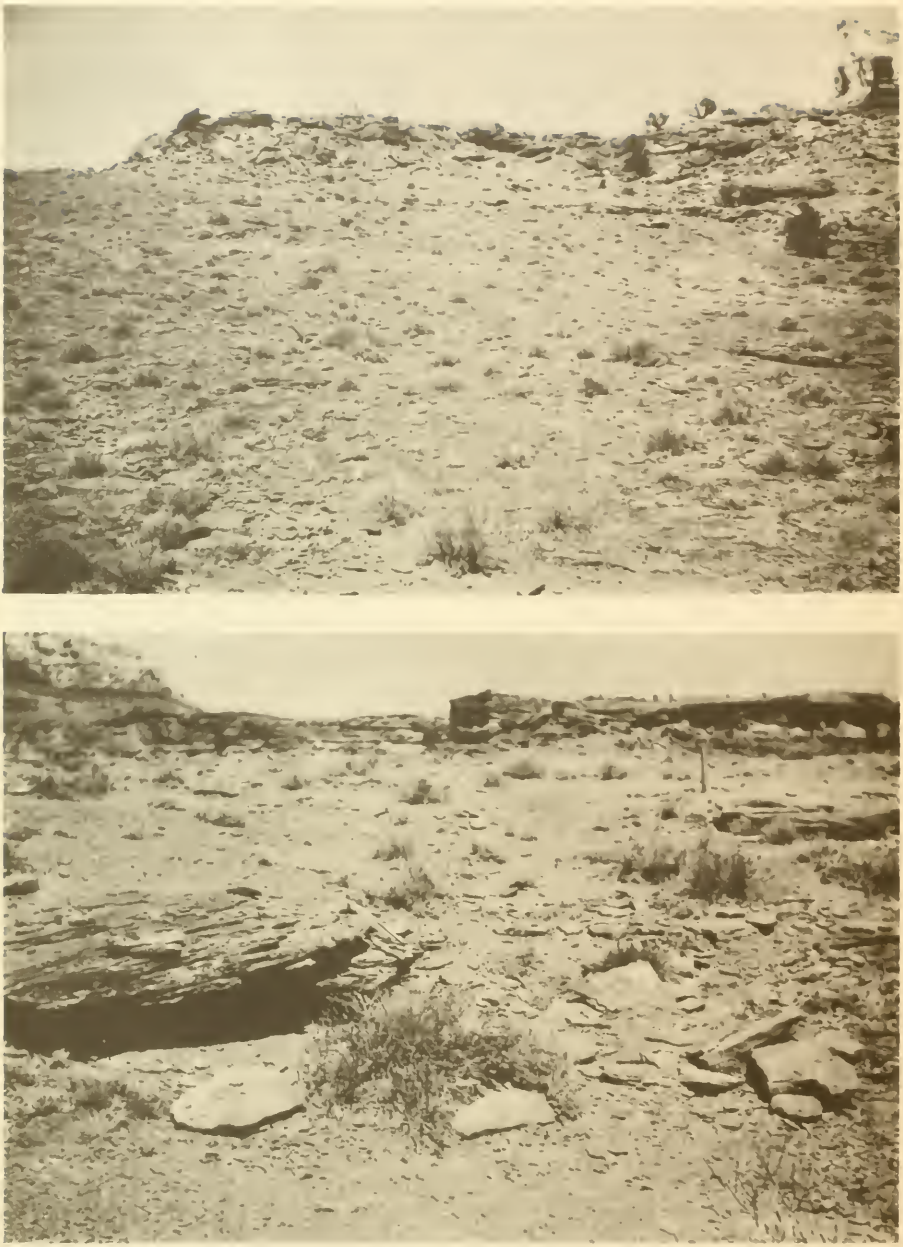
Stebbins, Robert C. 1954. Amphibians and reptiles of western North America. McGraw Hill Book Co., Inc., New York. 537 pp.

Tananka, R. H., Sugiyama and S. Teramura. 1958. A clumped distribution of trombiculid mites viewed from the true home ranges of host roles. Japanese Jour. Sanitary Zoology, 9:28-32.

Tanner, Wilmer W. 1963. Natural Radiation Effects on Vertebrate Animals inhabiting the Uranium Areas of Southeastern Utah, pp. 325-326. *In*: Radioecology, Proceedings of the First National Symposium on Radioecology held at Colorado State University, Fort Collins, Colorado, September 10-15, 1961. Vincent Schultz and Alfred W. Klement, editors. Reinhold Publ. Corp., New York and The American Institute of Biol. Sci., Washington, D. C., 746 pp.

Tanner, Wilmer W. and Clive D. Jorgensen. 1963. Reptiles of the Nevada Test Site. Brigham Young University Sci. Bull. 3(3):1-31.

Tinkle, Donald W., Don McGregor, and Dana Sumner. 1962. Home Range Ecology of *Uta stansburiana stejnegeri*. Ecology, 43(2):223-29.



Temple Mountain.

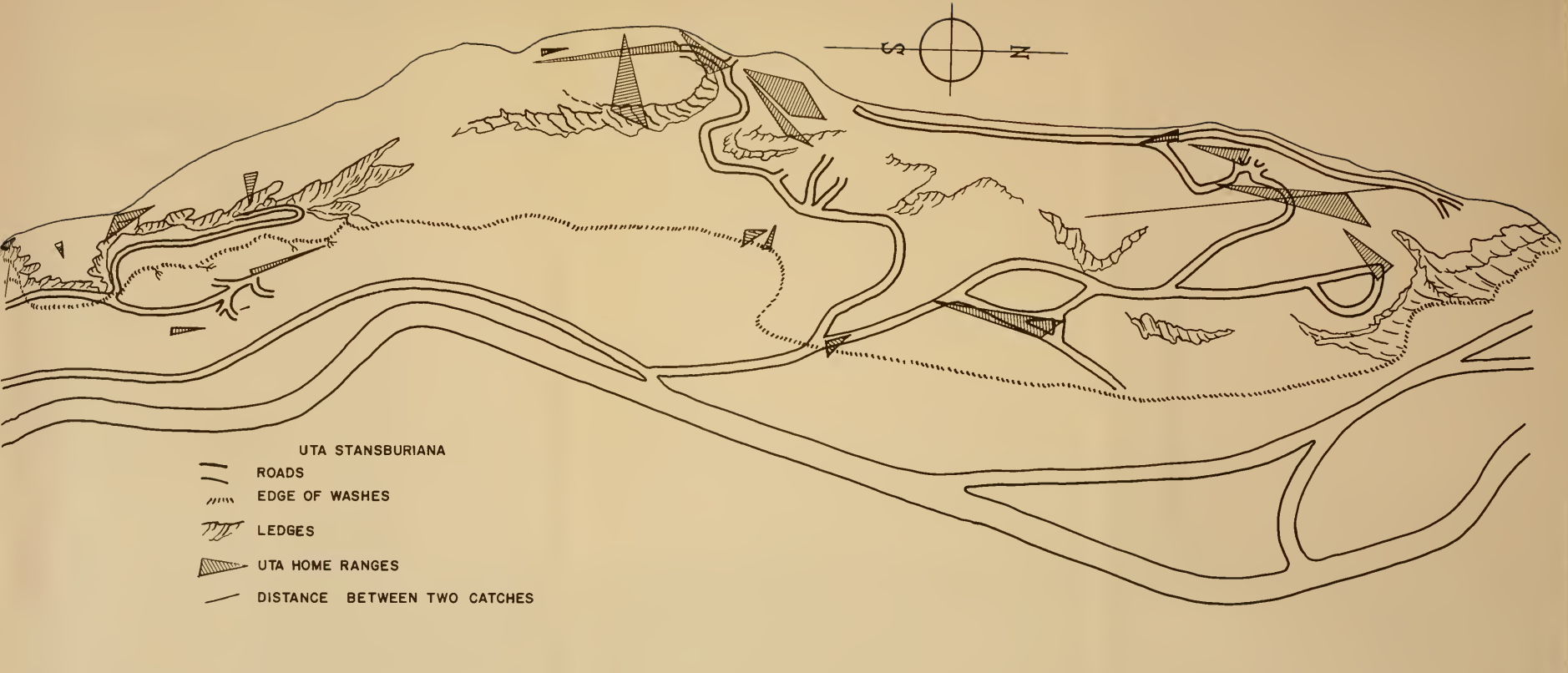


Fig. 5. A diagramatic sketch of the Temple Mountain area, showing the location of the home ranges of some *Uta stansburiana*. The legend provides the basic information.

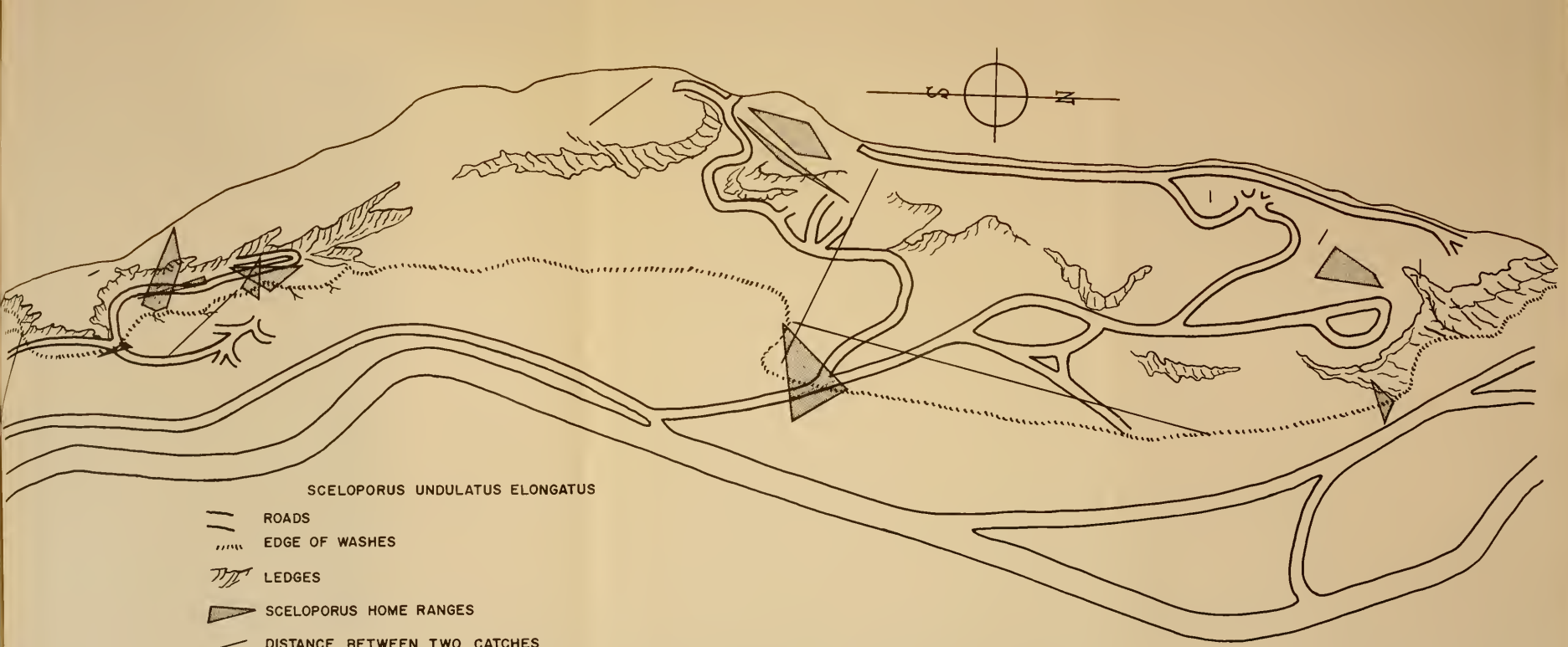


FIG. 6. A diagramatic sketch of the Temple Mountain area, showing the location of the home ranges of *Sceloporus undulatus elongatus*. The legend provides the basic information.

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SIPHONAPTERA (FLEAS) OF THE NEVADA TEST SITE

by
D ELDEN BECK
and
DORALD M. ALLRED

BIOLOGICAL SERIES — VOLUME VII, NUMBER 2
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SIPHONAPTERA (FLEAS) OF THE NEVADA TEST SITE[1]

by

D Elden Beck and Dorald M. Allred[2]

INTRODUCTION

Ecological studies at the Nevada Test Site near Mercury, Nevada, were begun in 1959 as a cooperative project between the United States Atomic Energy Commission and the Brigham Young University Department of Zoology and Entomology. Initial research was directed to mammals, birds and reptiles (Jorgensen & Hayward, 1965; Hayward, Killpack & Richards, 1963; Tanner & Jorgensen, 1963). As the investigations continued, however, parasites and other consortes were collected. Reports on some of these collections have been published (Goates, 1963; Beck, Allred & Brinton, 1963; Allred, 1963; Allred & Beck, 1963, 1964; and others—see list of references).

This report deals with data on the fleas collected at the Nevada Test Site. Geographical and ecological distribution, host relationships, and seasonal occurrence are emphasized. The biotic communities and areas of study were designated by Allred, *et al.* (1963 a & b), and our references generally follow their classification (Figs. 1 and 2).

LITERATURE REVIEW

Previous records of fleas from the Nevada Test Site are unknown, although there are reports for the state of Nevada. Every record from Nevada is not made here, but some general ones are worthy of mention.

Most reports of fleas for Nevada are the result of the extensive work by C. A. Hubbard (1947). Practically all references made by him are for collections made in the northern half of the state near or above the 39th parallel although there are some collections from southern Nevada. For example, *Hoplopsyllus anomalus* was taken from the White-tailed Antelope Squirrel (*Ammospermophilus leucurus*), and *Malaraeus sinomus* from the Deer Mouse (*Peromyscus maniculatus*) at Searchlight. *Hystrichopsylla gigas dippiei* (most likely *H. dippiei dippiei*) was collected from the Sonoran Deer Mouse (*P. maniculatus sonoriensis*) at Charleston Park on Charleston Mountain near Las Vegas. *Orchopeas sexdentatus nevadensis* was taken from the Desert Wood Rat (*Neotoma lepida*) from Clark County. Hopkins and Rothschild (1962) reported a contribution to the British Museum of *Anomiopsyllus amphibolus* taken from the White-throated Wood Rat (*Neotoma albigula*—most likely *N. lepida*) in Nye County. All localities are in the southeastern corner of Nevada, relatively near the test site.

METHODS AND PROCEDURES

Most of the fleas were taken from the bodies of host animals which were trapped or shot specifically for the purpose of collecting ectoparasites or selected from mammals and birds which were collected for other purposes. In each case the host was placed immediately into a paper sack which was then sealed, data written on it, and returned to the laboratory.

In some instances nests were removed from the houses or other recesses of the Desert Wood Rat, and the consortes extracted by the use of a modified Berlese funnel. Data contained with each collection included date, host or source, and the biotic community where found. These were coded for computer analysis.

Fleas were retrieved by brushing the fur of the host which was held under a 75-watt lamp

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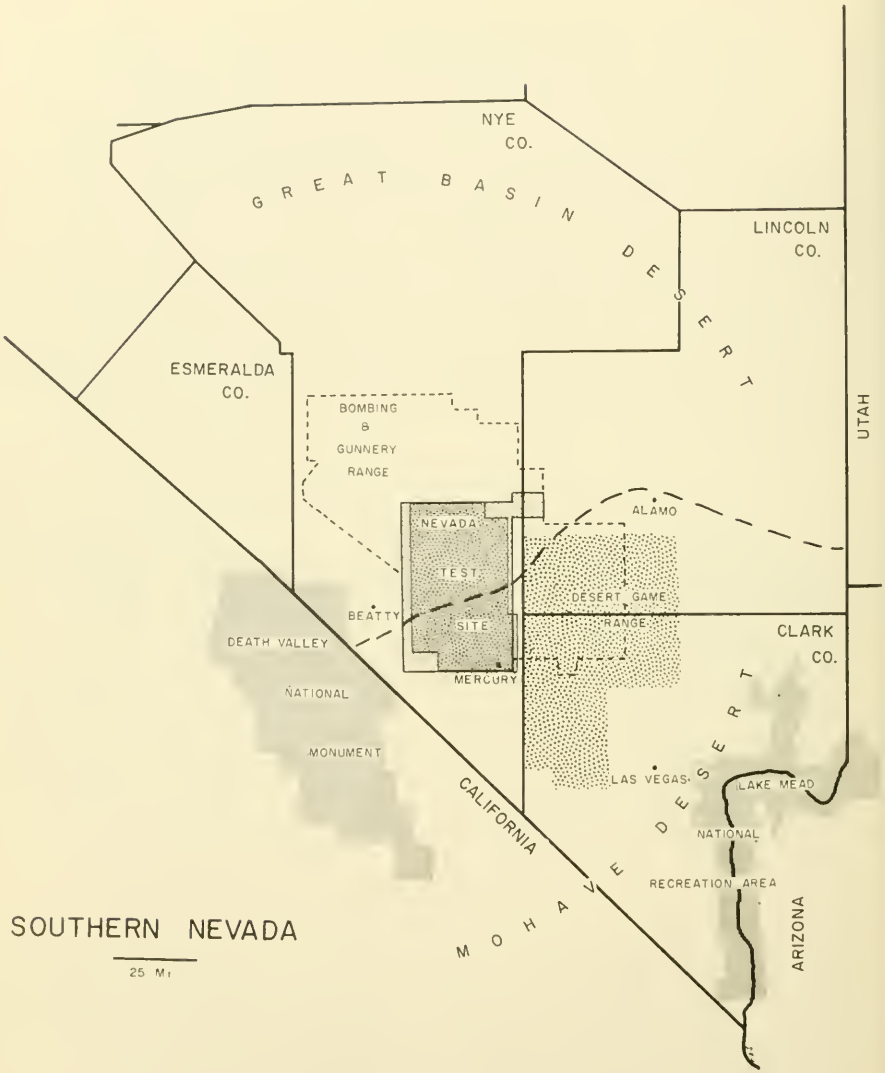

Fig. 1. Map of the southeastern corner of Nevada showing the regional location of the Nevada Test Site.

in a deep, white enamelware pan. All consortes were preserved in 70% ethyl alcohol until they were mounted individually on microslides to which were applied the collection data. Specimens were identified from the slide preparations, all data then placed on collection record forms, and IBM punch cards prepared to enable computer analysis.

ACKNOWLEDGMENTS

Many technicians were involved in the field collection and laboratory preparation of hosts and parasites. Without their careful work this study would not have been as readily accomplished. We are most grateful for their unselfish, enthusiastic participation.

Dr. William L. Jellison, Rocky Mountain Laboratory, Hamilton, Montana, corroborated and assisted in most of the flea determinations. Dr. Robert Traub, School of Medicine, University of Maryland, also helped to untangle some specific problems in flea determinations. This was likewise the case with Frank M. Prince, Communicable Disease Center, U. S. Public Health Service, San Francisco, California. Dr. C. Lynn Hayward, Department of Zoology and Entomology, Brigham Young University, Provo, Utah, helped with the specific identification of mammal and bird hosts.

We are especially grateful for the excellent laboratory services and transportation facilities which were provided by the Civil Effects Test Operations (CETO), Division of the Atomic Energy Commission, at Mercury, Nevada. We are likewise grateful for similar conveniences provided by Brigham Young University, Provo, Utah.

SCHEME OF CLASSIFICATION

In general we have followed the taxonomic and phylogenetic arrangement described by Hopkins and Rothschild (1953, 1956, 1962). Where special taxonomic studies have recently been made on specific groups, such as the genus *Thrassis* discussed by Stark (1958) and unpublished information on *Malaraeus* by Frank M. Prince, information as deemed appropriate has been judiciously inserted in the Hopkins-Rothschild arrangement. The species of fleas from the Nevada Test Site are listed below.

For the hosts we used the "Vernacular Names for North American Mammals North of Mexico" as approved by the American Society of Mammalogists (Hall, 1957).

FAMILIES AND SPECIES

Pulicidae

Echidnophaga gallinacea (Westwood)
Pulex irritans Linné
Cediopsylla inaequalis (Baker)
Hoplopsyllus anomalus (Baker)

Hystrichopsyllidae

Atyphloceras echis Jordan & Rothschild
Epitedia wenmanni (Rothschild)
Catallagia decipiens Rothschild
Meringis dipodomys Kohls
Meringis parkeri Jordan
Meringis hubbardi Kohls
Jordanopsylla allredi Traub & Tipton
Stenistomera alpina (Baker)
Callistopsyllus deuterus Jordan
Megarthroglossus procus Jordan & Rothschild
Anomiopsyllus amphibolus Wagner
Rhadinopsylla heiseri (McCoy)
Rhadinopsylla sectilis Jordan & Rothschild
Carteretta carteri Fox

Ceratophyllidae

Thrassis baechi (Rothschild)
Thrassis aridis Prince
Dactylopsylla bluei (Fox)
Foxella ignota (Baker)
Diamanus montanus (Baker)
Orchopeas sexdentatus (Rothschild)
Monopsyllus wagneri (Baker)
Monopsyllus eumolpi (Rothschild)
Malaraeus telchinum (Rothschild)

Malaraeus sinomus (Jordan)
Malaraeus euphorbi (Rothschild)

Amphipsyllidae

Amphipsylla neotomae Fox
Odontopsyllus dentatus (Baker)

Leptopsyllidae

Peromyscopsylla hesperomys (Baker)

Ischnopsyllidae

Nycteridopsylla vancouverensis Wagner

SPECIES PRESENTATION

For each species listed, the following sequence in presentation of information was followed: (a) specific and subspecific identity and other pertinent taxonomic data; (b) ecological and geographical distribution with maps; (c) host association; and (d) seasonal occurrence accompanied by graphs where sufficient populations made such presentation worthwhile. Seasonal occurrence was interpreted on the basis that a collection of fleas from a single host constituted an encounter, regardless of the number of fleas taken. For those species for which data are minimal, the presentations are given as summary statements without headings.

Some hosts at the test site were collected in greater numbers than others which were taken only occasionally during a particular season of the year. Although it is most unfortunate that all hosts at the test site were not collected on a daily schedule, it was considered not economically or conservationally feasible to do so.

Echidnophaga gallinacea (Westwood), 1875

Distribution. A total of 56 specimens was collected at widely separate parts of the site (Fig. 3). Too few specimens were collected to indicate a community predominance.

Host Associations. The Black-tailed Jack Rabbit (*Lepus californicus*) and the Kit Fox (*Vulpes macrotis*) were the only animals on which fleas of this species were found. The fleas were about equally distributed among those hosts collected.

Seasonal Occurrence. All specimens were found in August and December.

Comments. Sufficient data are not available to accurately delimit geographic boundaries. Extensive rabbit collections were made over several years at various seasons, yet only four rabbits were found infested, and then only with a single flea of this species on each rabbit.

According to Stark (1958) and Wheeler and Douglas (1945), *E. gallinacea* has been found naturally infected with plague organisms and demonstrated a high vector efficiency.

Pulex irritans Linné, 1758

Distribution. The greatest numbers of fleas collected were in the Grayia-Lycium community. This is one of several communities in the valleys where the most common host, the Kit Fox was collected. Geographically, the hosts and their fleas were widely distributed, especially along the foothills and in the valleys (Fig. 3).

Host Associations. Most of the 73 specimens obtained were collected from the Kit Fox. Other hosts were the Black-tailed Jack Rabbit, the Coyote (*Canis latrans*), and the Western Pipistrelle Bat (*Pipistrellus hesperus*) which represents an unusual collection. Fleas of this species have been taken in most abundance from burrowing animals, which may explain the greatest number found on the Kit Fox.

Seasonal Occurrence. Apparently fleas of this species are not restricted seasonally, but may be found at any month of the year when their host is active. Fleas were collected in January, February, May, August, and December.

Comments. To better understand the distribution and seasonal occurrence of *P. irritans* at the test site, a larger series of predators such as the Kit Fox, Coyote, and Bob Cat (*Lynx rufus*) need to be collected. Their dens also should be carefully examined. The records from the bat and rabbit most likely were accidental encounters.

Cediopsylla inaequalis (Baker), 1895

The male fleas collected indicate that the subspecies is *C. inaequalis interrupta* Jordan (1925).

Distribution. Most of the fleas (45 of 59) were taken from hosts from the Pinyon-Juniper

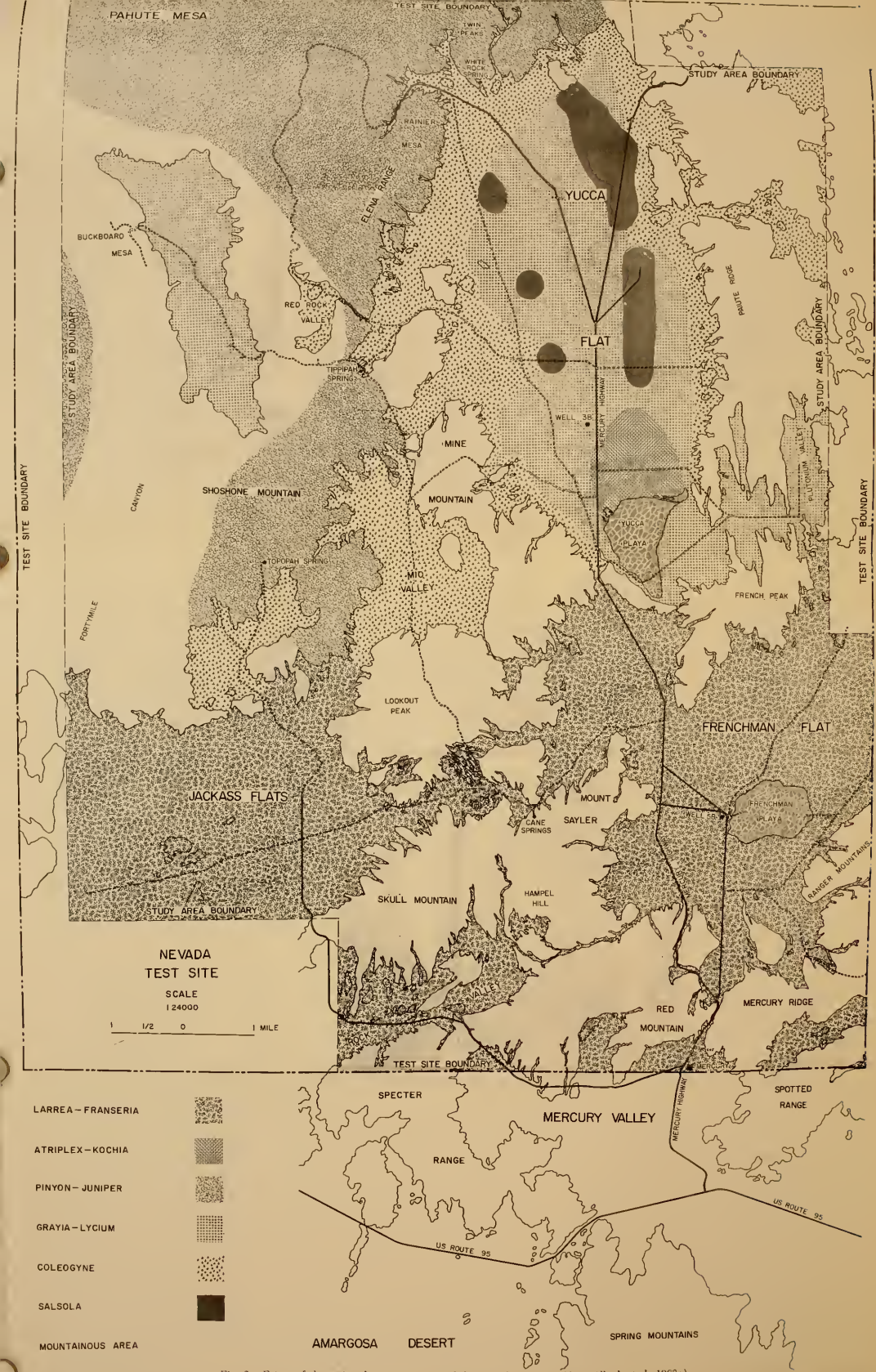

Fig. 2. Extent of the major plant communities of the Nevada Test Site (from Allred, *et al.*, 1963a).

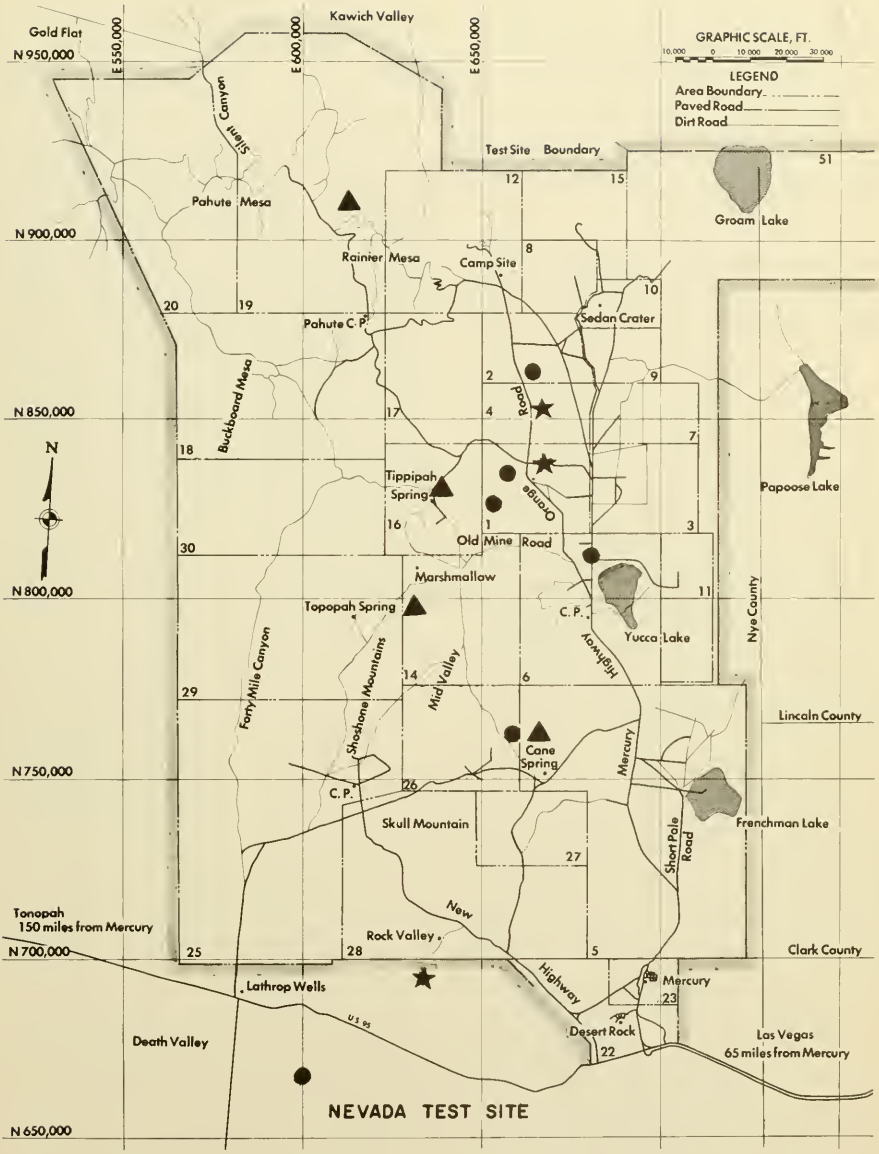

Fig. 3. Geographic distribution of *Echidnophaga gallinacea* ★ *Pulex irritans* ● and *Cediopsylla inequalis* ▲

community on Rainier Mesa. Thirteen were taken from the vicinity of Cane and Tippipah Springs which are in mixed vegetational communities. One collection was made in a Coleogyne community (Fig. 3).

Host Associations. The Rainier Mesa collections were from Nuttall's Cottontail Rabbit (*Sylvilagus nuttallii*). Thirteen specimens were collected from the Desert Cottontail Rabbit (*Sylvilagus audubonii*) and one from the White-tailed Antelope Squirrel.

Seasonal Occurrence. The greatest number of specimens was from a Nuttall's Cottontail Rabbit collected in April on Rainier Mesa. All others were collected in November from the Desert Cottontail Rabbit at lower elevations.

Comments. Extensive collections of mammals at the test site have not been made at the higher elevations, and collections at lower elevations have been limited in some instances. Although studies of the abundant mammalian fauna in the valleys and foothills have been carefully made, collections of cottontail rabbits living in the vicinity of springs on the desert have been limited to avoid their elimination by trapping and shooting. The vast areas of desert highland clothed with sage brush (*Artemisia tridentata*) in the western and northwestern part of the test site, and the extensive Pinyon-Juniper woodland to the north and northwest could well afford a close natural history scrutiny. These undoubtedly provide for an extended range for rabbits as well as other mammals and their ectoparasites.

Hoplopsyllus anomalus (Baker), 1904

Distribution. Fleas were taken from hosts in the valleys and foothills, and to a limited extent on Rainier Mesa. They were most frequently encountered in Grayia-Lycium, Larrea-Franseria, and Coleogyne biotic communities. Nevertheless, they were taken in all of the plant communities except Atriplex-Kochia. This is unusual, for the most common host, *A. leucurus*, was frequently collected from this latter community (Fig. 4).

Host Associations. Only a few Rock Squirrels (*Spermophilus variegatus*) were taken on Rainier Mesa in the Pinyon-Juniper community, but all possessed fleas. A Round-tailed Squirrel (*Spermophilus tereticaudus*) was collected in west Frenchman Flat, and two fleas were obtained. One flea was removed from the Little Pocket Mouse (*Perognathus longimembris*), and eight specimens from several Chisel-toothed Rats (*Dipodomys microps*). Most specimens (260 of 286) of *H. anomalus* were obtained from the White-tailed Antelope Squirrel.

Seasonal Occurrence. Most flea collections were made in June, with fewer encounters in April, May, and August. Two collections were made in September and one in December.

Comments. Collections of *H. anomalus* show them to occur in June, with a total absence in July, and reoccurrence in August. This was true regardless of elevation or host. These data should not be interpreted as conclusive, for there is a difference in the seasonal activity of the hosts from which fleas of this species have been taken. For example, one should not compare the seasonal occurrence for a species of flea on the Rock Squirrel with the same species on the White-tailed Antelope Squirrel. While the latter host is active during the winter in the valleys, the former may be hibernating in talus covered by snow at a much higher elevation. All specimens of *S. variegatus* were taken during April, May, and June, with the exception of one collection in August at the west side of Frenchman Flat along the foothills.

According to Stark (1958), fleas of this species in New Mexico have been found naturally infected with plague organisms.

Atyphloceras echis
Jordan and Rothschild, 1915

The subspecies of our collections is *A. echis echis*.

Distribution. Hosts and their parasites were confined primarily to the Coleogyne community. One specimen was taken in a mixed vegetational situation and one in a Pinyon-Juniper community (Fig. 5).

Host Association. Eleven fleas of this species were taken from the Desert Wood Rat.

Seasonal Occurrence. Collections were made in January and March, with most encounters in December.

Comments. Fleas of several species are known to live on *N. lepida* and in its nests. The natural history of the Desert Wood Rat and its parasites at the test site should be carefully studied, for the rats have a wide range of distribution at the site.

Epitedia wenmanni (Rothschild), 1904

Only two specimens were collected, a male and a female. On the basis of the male, this

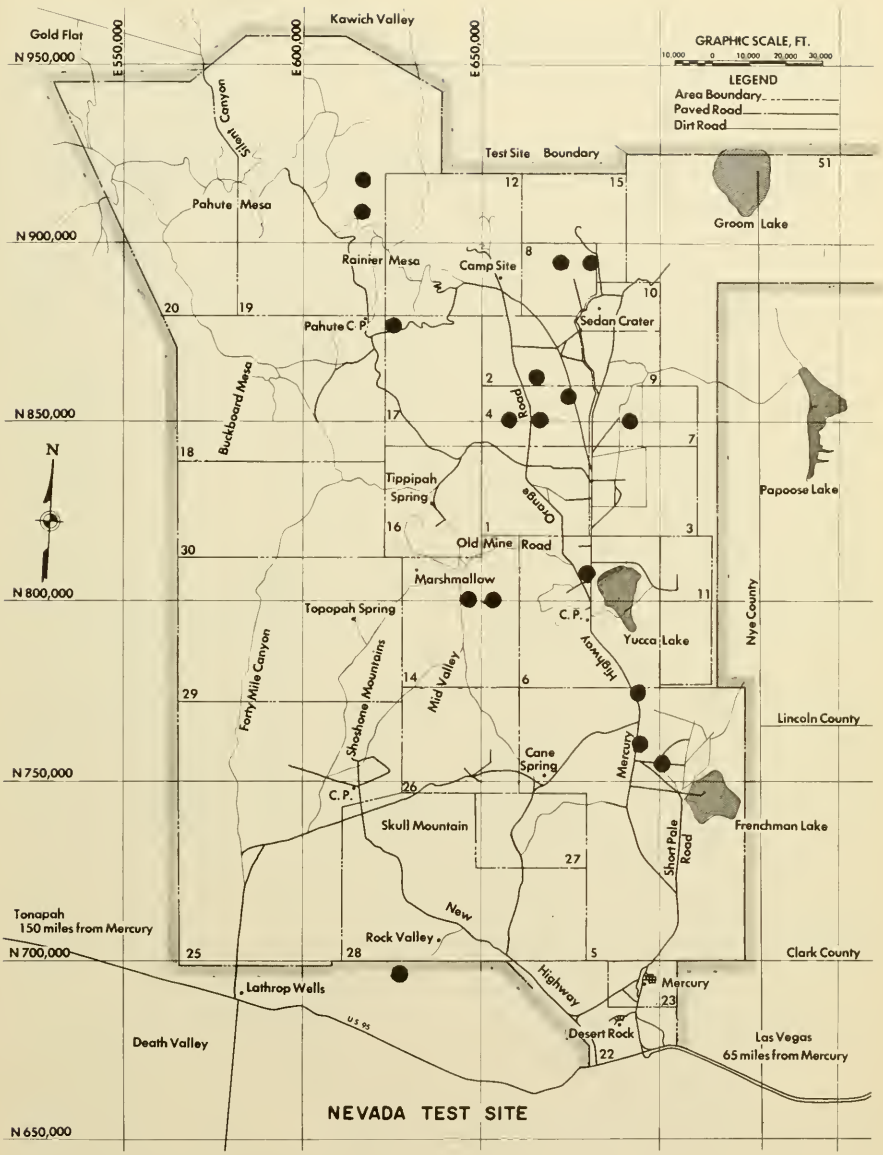

Fig. 4. Geographic distribution of *Hoplopsyllus anomalus*.

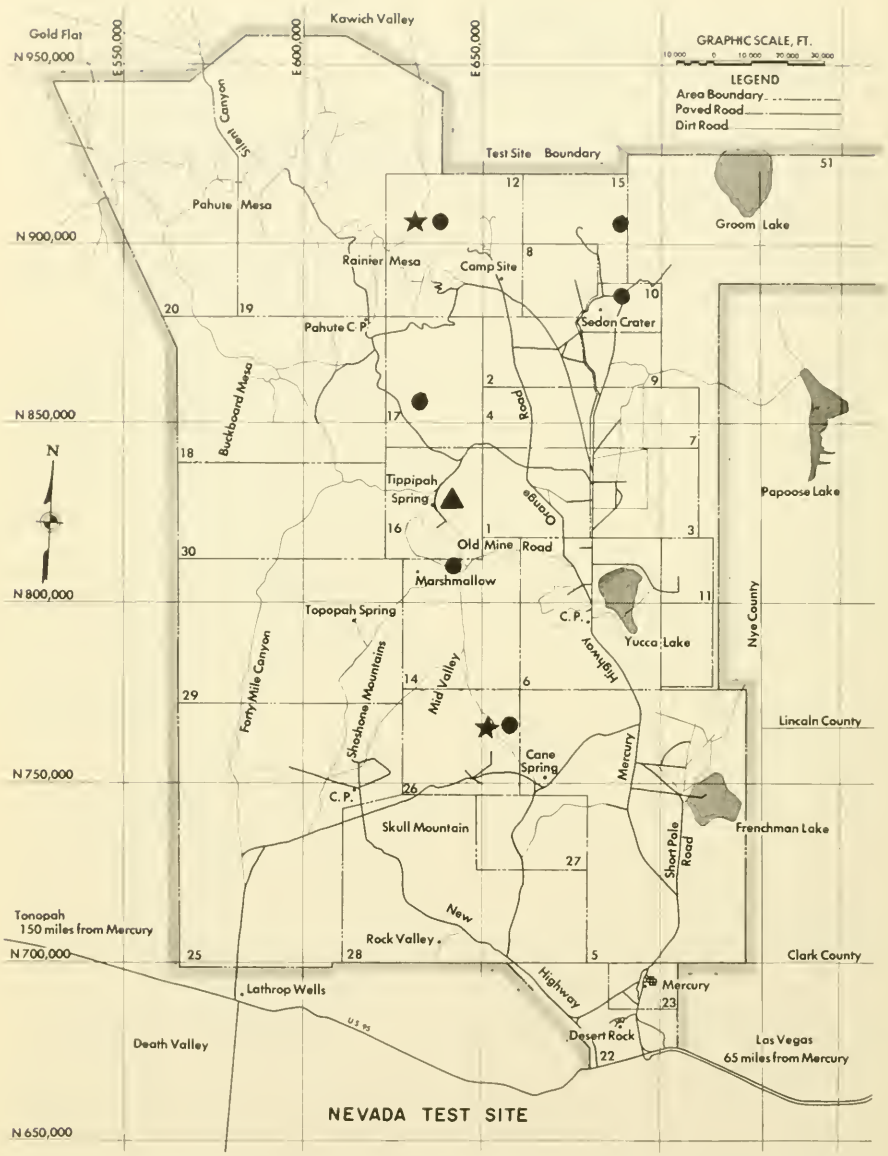

Fig. 5. Geographic distribution of *Atyphloceras echis* ● *Epitedia wenmanni* ▲ and *Catallagia decipiens* ★

is most likely of the subspecies *E. wenmanni wenmanni*.

Distribution. The two fleas were taken at Tippipah Spring, a mixed type of biotic community (Fig. 5).

Host Association. Both specimens were collected from a Western Pipistrelle Bat.

Seasonal Occurrence. The fleas were collected in November.

Comments. Many specimens of *Peromyscus* spp. and *N. lepida* were collected during this survey. It is unusual that we did not collect fleas of this species from these hosts. More unusual is that the only specimens taken were from a bat. In the original descriptions made in 1904, the male was taken from a White-footed Mouse (*Peromyscus leucopus*) and the female from a Bushy-tailed Wood Rat (*Neotoma cinerea*). Most published records show fleas of this species to occur on species of *Peromyscus* and *Neotoma*.

Catallagia decipiens Rothschild, 1915

Distribution. Hosts of two different species were collected, and one flea was collected from each. One was in a mountainous vicinity, the other in the Pinyon-Juniper community on Rainier Mesa (Fig. 5).

Host Associations. One host animal, a Pinyon Mouse (*Peromyscus truei*) was from Rainier Mesa; the other, a Desert Wood Rat, was in the vicinity of Tippipah Spring.

Seasonal Occurrence. The collection from *P. truei* was made in March, and from *N. lepida* in December.

Comments. The few collections of this species perhaps can be explained on the basis that fewer hosts have been collected at higher elevations at the test site compared to the number made in the valleys and foothills. In other surveys during the past 20 years and in literature references, the Deer Mouse has been the main host. Others mentioned in the literature are mainly mammals whose habitats are at high elevations or in cool environs. *Peromyscus maniculatus* at the test site is most abundant in the Pinyon-Juniper community which has not been extensively surveyed by us.

Meringis dipodomys Kohls, 1938

Distribution. Fleas of this species were the ones most commonly encountered at the test site. This is due to the wide distribution and abundance of their common hosts, kangaroo rats. These mammals were under continuous study for several years, primarily in the valleys and foothills where they are most usually found. From the standpoint of biotic community distribution, many collections were from Larrea-Franseria with about equal numbers from Coleogyne and Grayia-Lycium. The next ranking community was Salsola, with few collections from mixed vegetative communities. Two collections were in Pinyon-Juniper, and one was in Atriplex-Kochia (Fig. 6).

Host Associations. As the specific name of the flea indicates, the most common hosts are species of *Dipodomys*. The Chisel-toothed Kangaroo Rat is the species on which these fleas were most often encountered. The next was Merriam's Kangaroo Rat (*Dipodomys merriami*). Only two collections were taken from the large Desert Kangaroo Rat (*Dipodomys deserti*) which is so restricted in its distribution that not many collections were expected. A single collection was made from Ord's Kangaroo Rat (*Dipodomys ordii*). Other animals from which fleas were taken, in order of abundance, are the White-tailed Antelope Squirrel, the Southern Grasshopper Mouse (*Onychomys torridus*), the Desert Wood Rat, the Great Basin Pocket Mouse (*Perognathus parvus*), the Deer Mouse and the Kit Fox.

Seasonal Occurrence. Fleas of this species were not taken in May, July, or August, and only one collection was made in June when three males were taken from *D. microps*. Most collections were made in October and November. The common hosts, *Dipodomys* spp., were present during these months, and many were trapped and examined during May, June, July, and August as well as in other months. Two collections were made in September, 32 in October, and 86 in November. A relatively high incidence was maintained throughout the fall, winter, and early spring until May (Fig. 7).

Comments. Kangaroo rats of several species and the White-tailed Antelope Squirrel were studied extensively at the test site. This provided an opportunity to examine their ectoparasite fauna on a year-round basis.

The disappearance of adult flea populations during May, June, July, and August is an enigma. The host is active during the summer months, but fleas were not found on those examined during that period. One might surmise that fleas of this species are sensitive to the high temperatures during the hot summer

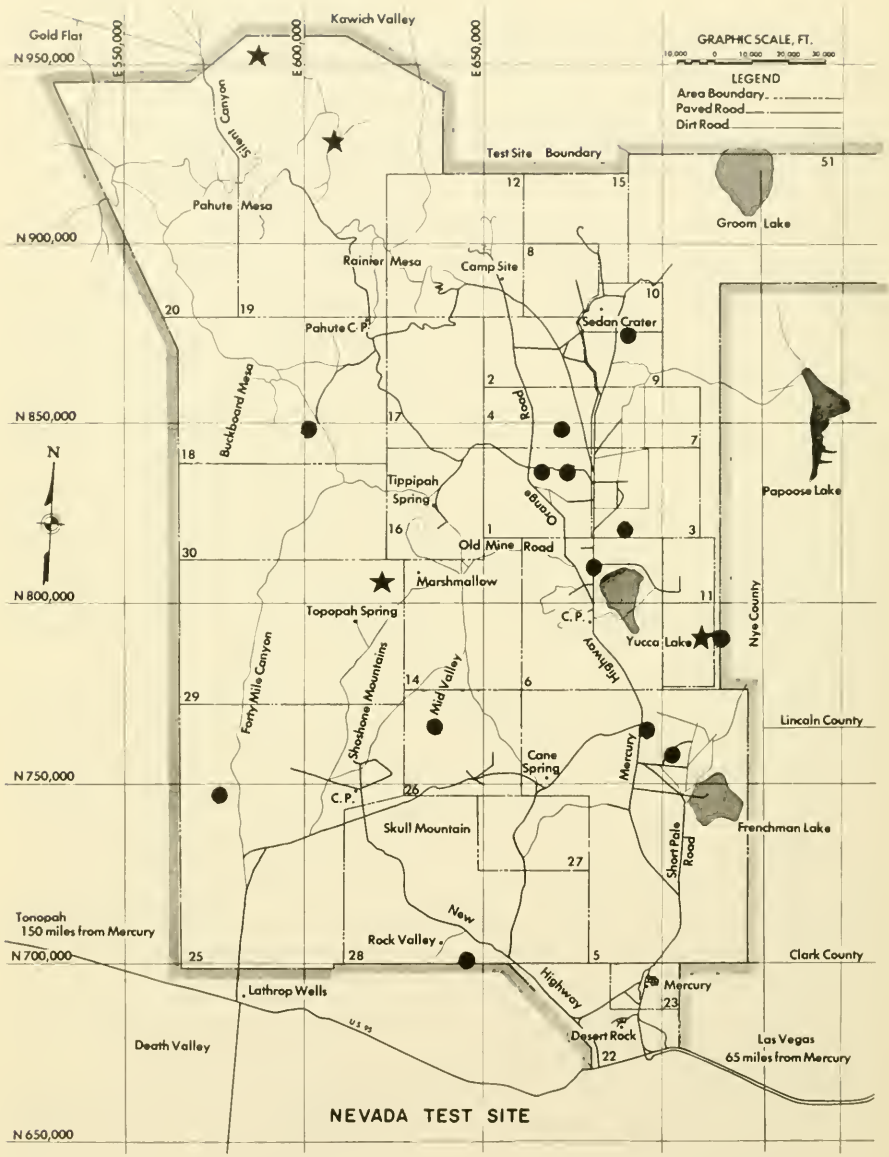

Fig. 6. Geographic distribution of *Meringis dipodomys* ● and *Meringis parkeri* ★

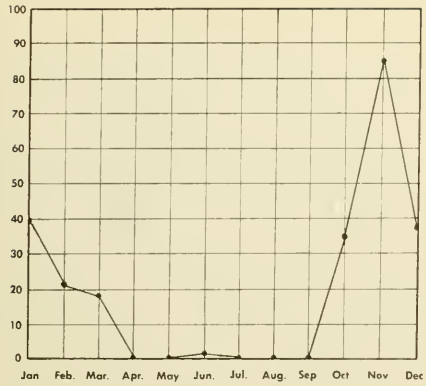

Fig. 7. Seasonal occurrence of *Meringis dipodomys*. The figures on incidence do not represent total numbers of specimens taken during the month, but indicate the total number of collections (encounters) wherein fleas were found.

period and perhaps exist in the nests as an immature stage—egg, larva, or pupa—until cooler temperatures occur.

Meringis parkeri Jordan, 1937

Distribution. All collections were made from hosts taken on the high mesas or along the foothills. Collections came from the Coleogyne, Pinyon-Juniper, and mixed biotic communities, as well as Artemisia associations. Most encounters were from mixed vegetative situations (Fig. 6).

Host Associations. With the exception of one collection from the Deer Mouse, the remainder were about equally encountered from the Great Basin Pocket Mouse, Merriam's Kangaroo Rat, the Chisel-toothed Kangaroo Rat, and Southern Grasshopper Mouse.

Seasonal Occurrence. The 16 specimens taken occurred in the same pattern as *M. dipodomys*. Collections were taken in September, December, March, and April with no encounters in other months, although the usual hosts were collected during all months of the year.

Comments. This species was originally described from specimens from *Dipodomys* sp. taken at Powderville, Montana. From literature references and twenty years of field studies of fleas, one may assume that the most likely host is Ord's Kangaroo Rat. This is especially true for the Great Basin Province. *Dipodomys ordii* has a scattered distribution at the test site—northward it is predominant, but southward it is replaced by *D. merriami*. Nevertheless, *D. ordii* that were collected did not produce a specimen of *M. parkeri*.

Meringis hubbardi Kohls, 1938

Distribution. All specimens were taken at higher elevations, principally on Rainier Mesa in the northwestern portion of the test site. All were in the Pinyon-Juniper biotic community, except one from the Gold Meadow area north of Rainier Mesa, a region predominantly vegetated by the sage brush, *Artemisia tridentata* (Fig. 8).

Host Associations. Three collections were from the Great Basin Pocket Mouse, two from the Chisel-toothed Kangaroo Rat, and one from the Little Pocket Mouse.

Seasonal Occurrence. All collections were made in September except one in April.

Comments. The lack in numbers and breadth of distribution of this species may be related to the higher elevations where its hosts more commonly occur, areas not so extensively surveyed by us.

Jordanopsylla allredi
Traub and Tipton, 1951

Fleas of this genus and species were described by Traub and Tipton (1951) from females taken from the Cactus Mouse (*Peromyscus eremicus*) at Grafton, Washington County, Utah, the western gateway to Zion National Park.

In our investigations three males and two females of *J. allredi* were collected.

Distribution. All specimens of fleas were collected from *N. lepida* at the southern boundary of the test site. Hosts were taken from rocky ledges in a mixed vegetative biotic community in each instance (Fig. 8).

Host Associations. Although the first collection was from the Cactus Mouse in Southern Utah, it seems probable that the principal host will eventually be shown to be the Desert Wood Rat. We collected the type specimens of this genus and species and are well acquainted with the habitats where both the initial and later collections were made. It is on these observations that we make the tentative host-preference designation.

Seasonal Occurrence. Fleas were taken in October and November.

Comments. Many specimens of *N. lepida* and their nests at the test site were examined during

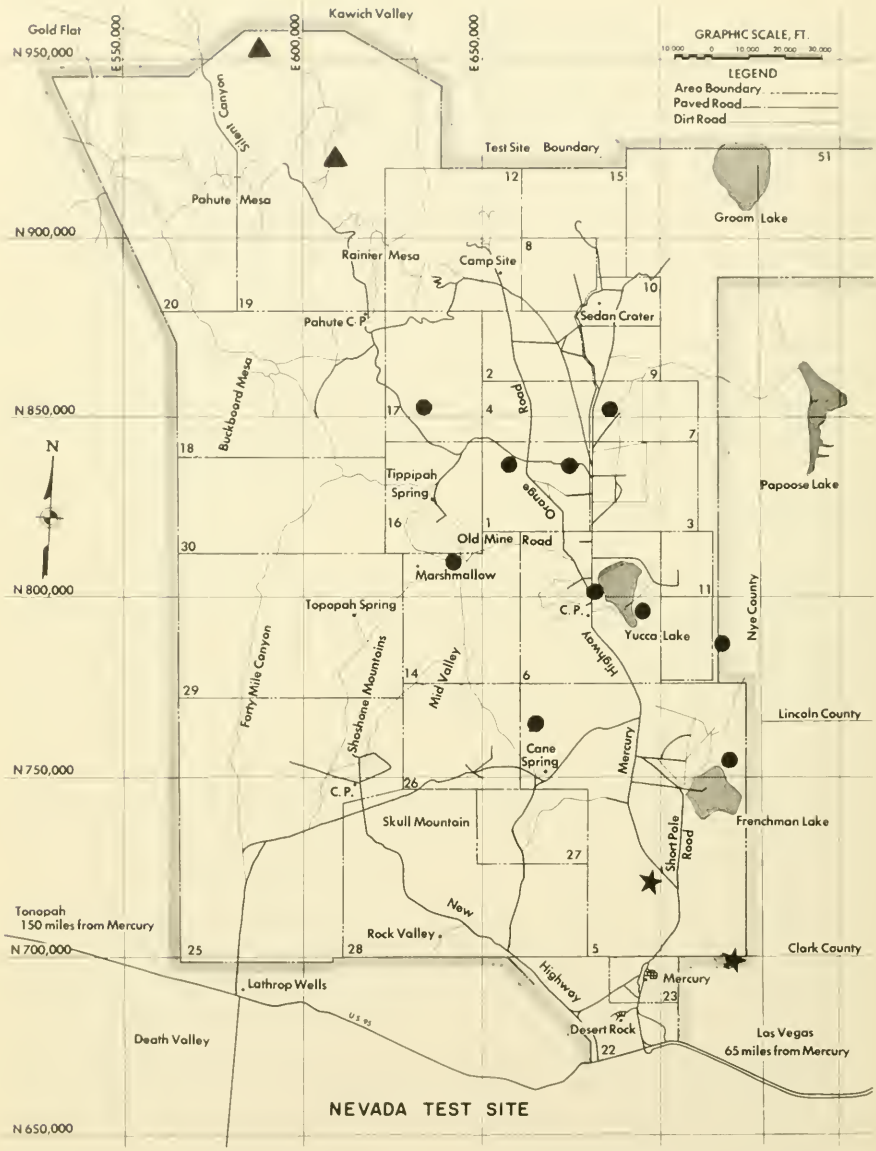

Fig. 8. Geographic distribution of *Meringis hubbardi* ▲ *Jordanopsylla allredi* ★ and *Stenistomera alpina* ●

the summer of 1965 without obtaining a single flea of this species. Collections of nests were made in the same locality where fleas of this species previously had been collected. The study of Howell (1955) revealed a very low population of all species of fleas in the nests of *N. lepida* in Utah during the summer periods. The specimens from which the original descriptions were made were collected in December and November.

Stenistomera alpina (Baker), 1895

Distribution. Fleas of this species have been considered by some workers as rare in occurrence. In our studies at the Nevada Test Site, they occurred commonly on the Desert Wood Rat at some seasons of the year. This host is not restricted to any one biotic community at the test site, but is found in the Pinyon-Juniper, Coleogyne, Salsola, Larrea-Franseria, and Grayia-Lycium communities. About the only restrictive influence affecting its distribution is the absence of house-building materials, rocky ledges, or large shrubs in which a house may be constructed with appropriate situations for nesting either in the house or in close association with it. Most of the fleas were collected from hosts trapped in the mixed biotic communities (Fig. 8).

Host Associations. The Desert Wood Rat is the principal host. Six fleas were taken from a Canyon Mouse (*Peromyscus crinitis*), and three from a White-tailed Antelope Squirrel.

Seasonal Occurrence. Extensive collections of the Desert Wood Rat were not made continually throughout any one year. A collecting schedule set up to include the months of October, November, December, and January resulted in thirty collections in December compared to only four encounters each for January, October, and November. During the summer months of 1965 (June, July, August), collection of *N. lepida* and its nests was emphasized. Seven fleas of this species were taken from one nest in June. None was found in 58 other nests collected during the summer.

Comments. Although the principal host, the Desert Wood Rat, is widely distributed, there seems to be some relationship between the presence of fleas of this species and the seasonal occurrence of the rat.

Callistopsyllus deuterus Jordan, 1937

The only specimen of this species taken is a male from a Canyon Mouse. Hubbard (1947: 281) stated: "The two species (of *Callistopsyllus*) come consistently off deer mice, occasionally off other rodents." This has been our experience in many years of collecting in Utah. The host, *P. crinitis*, has been collected in most months of the year and at widely-separated parts of the test site, mainly along the foothills in mixed communities; yet this is the only flea of this species we have taken (Fig. 9).

Megarthroglossus procus
Jordan and Rothschild, 1915

Insofar as we can determine, our single specimen belongs to the subspecies *M. procus procus*. The male was collected from a Desert Wood Rat in the vicinity of Tippipah Spring in a Coleogyne biotic community in November (Fig. 9).

Anomiopsyllus amphibolus
Wagner, 1936

Distribution. This species was taken at widely-separated points at the test site, but most frequently at the northwestern part along the foothills or at higher elevations. The biotic community association was mainly with Pinyon-Juniper, Grayia-Lycium, and in mixed vegetative types (Fig. 9).

Host Associations. One collection each was made from a pocket mouse, Deer Mouse, Pinyon Mouse, and Cactus Mouse. Five separate encounters were with the Desert Wood Rat.

Seasonal Occurrence. Two collections were made in March, one in April, six in October, and one in December.

Comments. In Utah studies, hundreds of specimens of *A. amphibolus* were found in the nests of *N. lepida*, whereas few were taken from the host's body (Beck *et al.*, 1953; Howell, 1955). During June, July, August, and September collections in Utah, nests were relatively free of fleas of this species compared to other months of the year. Nests were not examined during fall, winter, and spring months at the test site.

The collection of this flea from the host's body indicates a similarity of occurrence at the test site and in collections made in Utah. Additional support to this view are our studies during the summer of 1965. More than fifty nests of *N. lepida* were collected, but not a single flea of any species was found. We did take seven specimens of *Stenistomera alpina* from one host, but *A. amphibolus* was not encountered.

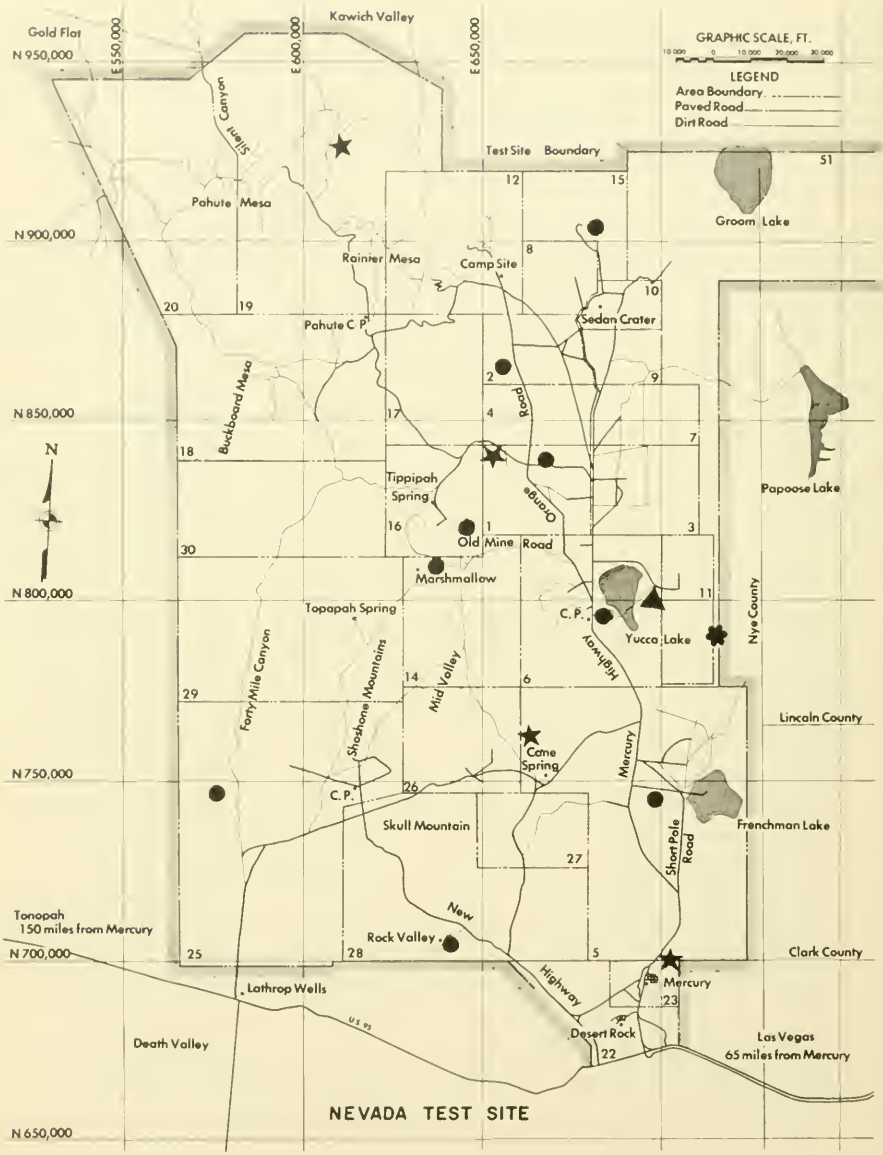

Fig. 9. Geographic distribution of *Callistopsyllus deuterus* ▲ *Anomiopsyllus amphibolus* ★ *Megarthroglossus procus* ✱ and *Rhadinopsylla heiseri* ●

Rhadinopsylla heiseri (McCoy), 1911

This species has been listed as *Actenopthalmus heiseri* in some publications. We follow the taxonomic placement by Hopkins and Rothschild (1962) in which *Actenopthalmus* is listed as a subgenus and the generic status is *Rhadinopsylla*. According to Jellison (personal correspondence), there is a close relationship between *heiseri* and *multidenticulata* of Morlan and Prince (1954). Nevertheless, we feel these specimens more closely fit the description for *heiseri*.

Distribution. Most of the 127 fleas collected of this species were taken from hosts found in mixed vegetation communities in Jackass Flats at the southwestern part of the test site. The next most often encountered collections were in Larrea-Franseria communities in the southeastern section. Another community with about equal encounters is the Coleogyne community in the northeastern part. All other communities except the Pinyon-Juniper produced occasional collections (Fig. 9).

Host Associations. The host on which most fleas of this species were taken is the White-tailed Antelope Squirrel. Occasional collections were also made from the Desert Kangaroo Rat, Chisel-toothed Kangaroo Rat, Southern Grasshopper Mouse, and Southern Pocket Gopher (*Thomomys umbrinus*). *Onychomys torridus* is a predator and thus may be expected to have fleas from various rodent victims.

Seasonal Occurrence. Most collections were in January, with December, November, and February ranking in relative sequence for other collections. Only one collection was made in March, one in April, and one in October. Fleas were not found in other months of the year.

Comments. The original description of this species made by McCoy (1911) was of a female taken at Mojave, California. The host is unknown for that collection, but in later collections by several workers, the most common host encountered was the White-tailed Antelope Squirrel. Hubbard contributed a male and female of this species which he had collected in December of 1949 at Carson City, Nevada, to the British Museum in 1950. These were from *A. leucurus*. The great majority of our collections were likewise from this same host. No doubt the instances of occurrence on hosts other than *A. leucurus* are accidental, for several species of animals live in close association with this squirrel.

Rhadinopsylla sectilis
Jordan and Rothschild, 1923

Rhadinopsylla sectilis was listed by Hubbard (1947) and Holland (1949) as *Micropsylla sectilis*. Hopkins and Rothschild (1962) listed *Micropsylla* as a subgenus of *Rhadinospsylla*. As far as we can determine, our specimens are of the subspecies *R. sectilis sectilis*.

Distribution. Most hosts were taken in the Grayia-Lycium community. A few encounters were from Larrea-Franseria and Coleogyne. The geographical distribution was generally in Yucca and Frenchman Flats (Fig. 10).

Host Associations. The Chisel-toothed Kangaroo Rat is the host on which fleas of this species were most commonly encountered. The next most common host is the White-tailed Antelope Squirrel. One specimen was removed from *O. torridus*, and three were from Merriam's Kangaroo Rats.

Seasonal Occurrence. About equal numbers were collected during January, February, March, and December. One specimen each was taken in October and November.

Comments. Apparently fleas of this species are not abundant on a variety of hosts. Collections of such hosts as *P. maniculatus* at higher elevations may produce a greater number of specimens.

Carteretta carteri Fox, 1927

Dr. William L. Jellison (personal correspondence) is of the opinion that these fleas are of the subspecies *C. carteri clavata*.

Distribution. The geographical and ecological distribution is throughout Frenchman and Yucca Flats. Most encounters were in the Larrea-Franseria community, followed by Coleogyne and mixed vegetative communities (Fig. 10).

Host Associations. Three collections (total of seven fleas) were taken from the Long-tailed Pocket Mouse (*Perognathus formosus*). One specimen each was from a Merriam's Kangaroo Rat, a Canyon Mouse, and a White-tailed Antelope Squirrel.

Seasonal Occurrence. Specimens were taken in March, April, October and November.

Comments. The occasional appearance of this flea on Merriam's Kangaroo Rat and the White-tailed Antelope Squirrel may be accidental, for only a few of several hundred of these hosts that were examined were infested with

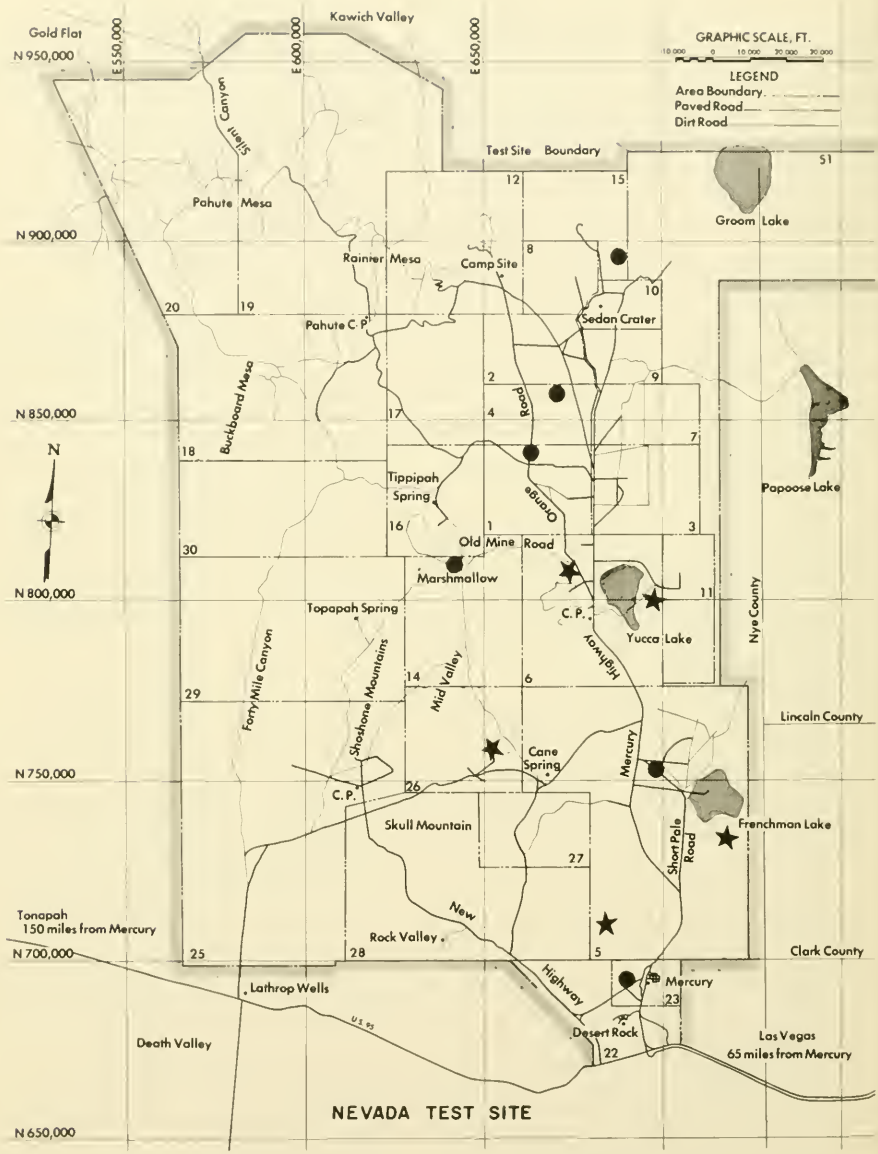

Fig. 10. Geographic distribution of *Rhadinopsylla sectilis* ● and *Carteretta carteri* ★

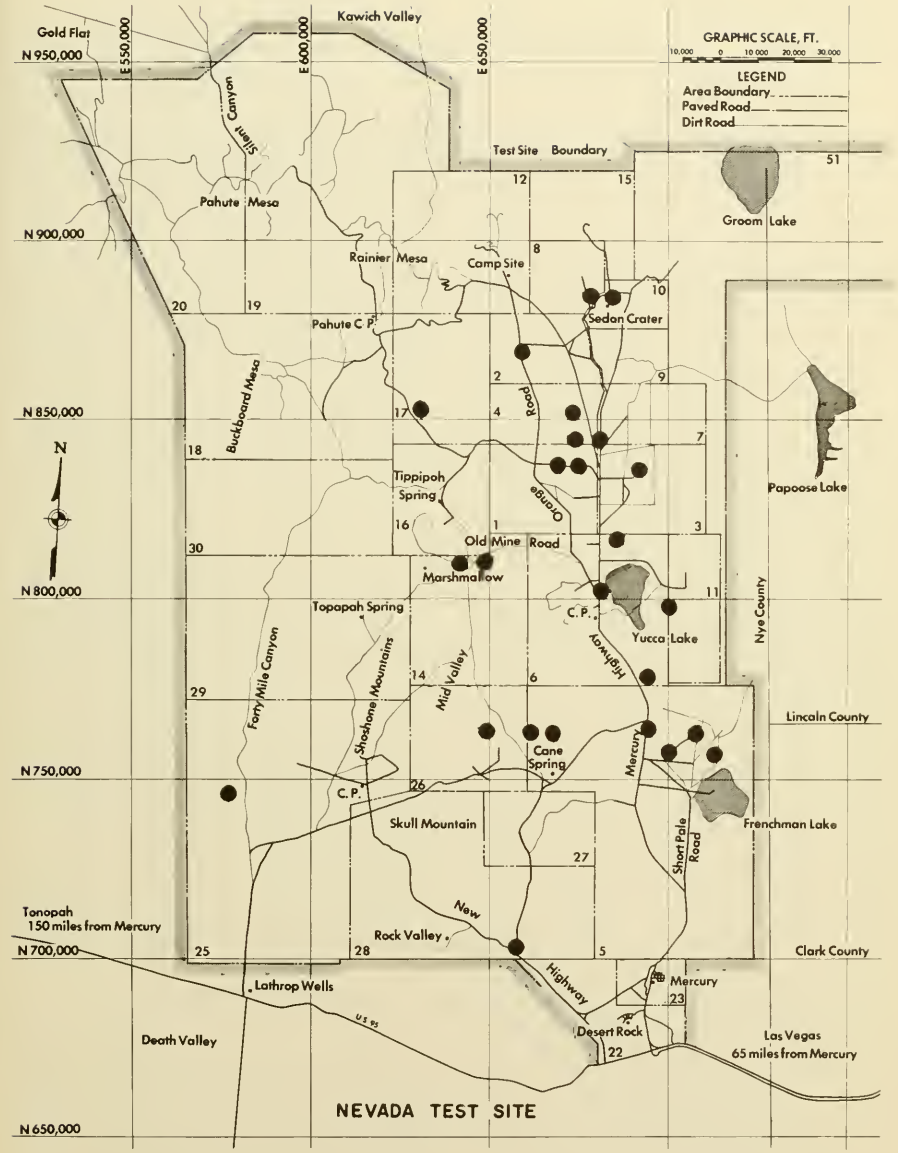

Fig. 11. Geographic distribution of *Thrassis bacchi*

fleas of this species. Of the many mice examined during the five-year period, only six specimens of *C. carteri clavata* were taken. It is possible that fleas of this species occur in low density.

Thrassis bacchi (Rothschild), 1905

A total of 1,491 specimens of this species was collected during the period of this study, making it the most abundant flea at the test site. Using Stark's (1958) publication on Utah Siphonaptera as a guide, we conclude that the subspecies is *T. bacchi gladiolus*.

Distribution. The hosts from which the fleas were taken are principally valley and foothill inhabitants. They were found in all communities relegated to these elevations (Fig. 11).

Host Associations. The White-tailed Antelope Squirrel was most often encountered as the host. The Southern Grasshopper Mouse was the next most prominent host, with the Chisel-toothed Kangaroo Rat about equal in host preference. Other hosts on which specimens were infrequently taken are Merriam's Kangaroo Rat, the Desert Kangaroo Rat, Little Pocket Mouse, Canyon Mouse, Pinyon Mouse, and Coyote.

Seasonal Occurrence. There were about equal numbers of collections made during most of the months of the year except the summer months of July and August (Fig. 12). There was an absence of fleas in July, and only one specimen was taken in August. White-tailed Antelope Squirrels were collected during the summer, but they did not possess fleas.

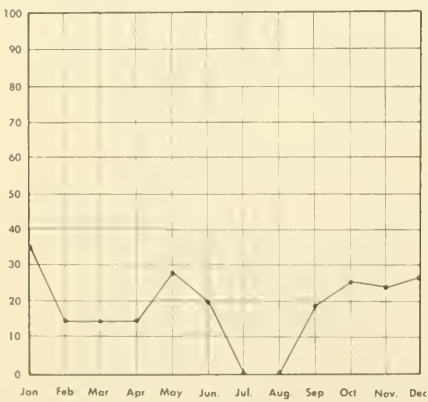

Fig. 12. Seasonal occurrence of *Thrassis bacchi*. The figures on incidence do not represent the total numbers of specimens taken during a month, but indicate the total number of collections (encounters) made wherein fleas were found.

Comments. Fleas of this species reflect the general pattern of seasonal distribution of other fleas at the lower elevations of the test site where the incidence of occurrence is greatly reduced during the summer months. Burrow examination and nesting site collections would be a worthwhile endeavor, for they might help determine what happens to the adult flea populations during the summer months.

Thrassis aridis Prince, 1944

According to Stark's keys and descriptions (1958), our specimens are *T. aridis hoffmani*. This species ranks next to *T. bacchi gladiolus* in abundance at the test site.

Distribution. There was widespread distribution at the test site in the biotic communities of the valleys and foothills. Most of the fleas came from the Gravia-Lycium, Coleogyne, Larrea-Franseria, and Salsola communities (Fig. 13).

Host Associations. *Thrassis aridis hoffmani* was most often encountered on the Chisel-toothed Kangaroo Rat. Merriam's Kangaroo Rat was the next most frequently infested, with the White-tailed Antelope Squirrel producing occasional specimens. One to five encounters were made with the Southern Grasshopper Mouse, Kit Fox, Canyon Mouse, Southern Pocket Gopher, Long-tailed Pocket Mouse, and Rock Squirrel.

Seasonal Occurrence. The greatest numbers were collected in November, followed by October, December, and January. Incidental collections made at other times of the year were one each in June and August (Fig. 14).

Comments. The same picture for seasonal distribution as seen in others is also reflected in this species. Summer incidence is low or lacking, with the highest being late fall to midwinter.

Dactylopsylla bluei (Fox), 1909

Foxella and *Dactylopsylla* are variously used by workers in generic designation for pocket gopher fleas. There is sufficient difference in genital anatomy alone to separate them as two distinct genera, and we follow Prince (1945) and Holland (1949) in this arrangement. Specimens of *D. bluei* were submitted to Dr. W. L. Jellison who recommended the subspecific designation of *D. bluei psilos*

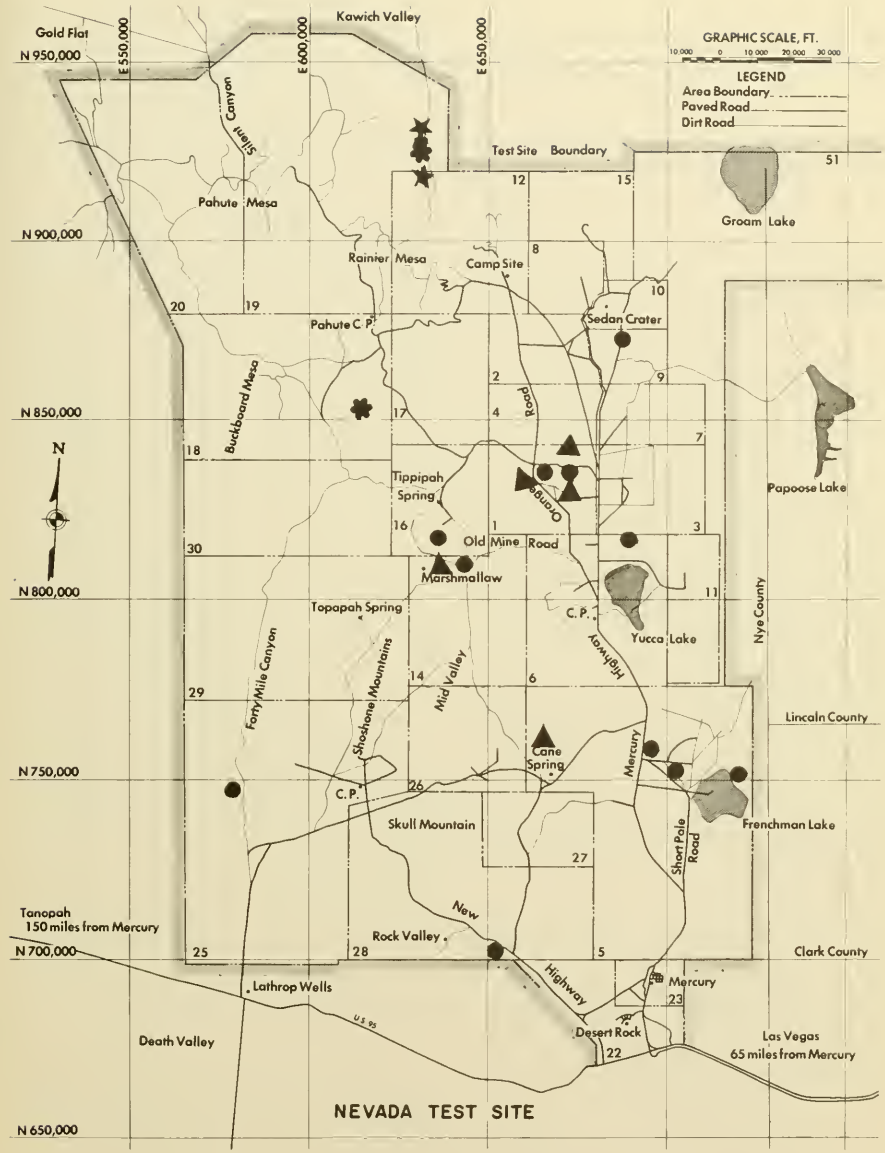

Fig. 13. Geographic distribution of *Thrassis aridis* ● *Foxella ignota* ✽ *Dactylopsylla bluei* ▲ and *Diamanus montanus* ★

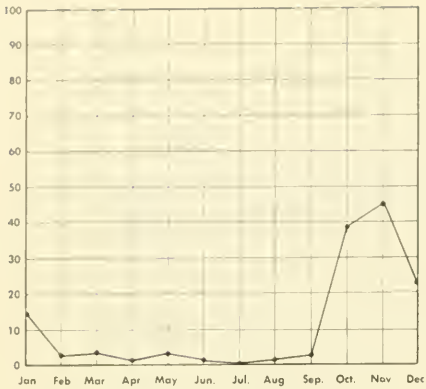

Fig. 14. Seasonal occurrence of *Thrassis aridis*. The figures on incidence do not represent total numbers of specimens taken during the month, but indicate the total number of collections (encounters) wherein fleas were found.

Distribution. Most of the specimens were from gophers trapped in Gravia-Lycium communities. A few were from Coleogyne and some from mixed vegetational types. One flea was collected from an area of much gopher activity in the west-central area of the test site which is at a higher elevation in an Artemisia association (Fig. 13).

Host Associations. The Southern Pocket Gopher was the principal host. Collections were also made from the Southern Grasshopper Mouse and from an unknown species of pocket mouse.

Seasonal Occurrence. Collections were made during January, February, March, May, June, July, and September. Most of them were encountered in March.

Comments. The principal host for this flea is *T. umbrinus*, although it is occasionally found on other mammals living in the same vicinity. Before a true picture on host relationships, seasonal occurrence, and distribution may be seen, more concentrated surveys will have to be made in all of the biotic communities, especially in the western half and at higher elevations of the test site.

Foxella ignota (Baker), 1895

Only two hosts were found infested with fleas of this species. A Desert Cottontail collected in a Larrea-Franseria community yielded sixteen fleas. An unusual record was the extraction of 121 fleas from a Southern Pocket Gopher which was collected from a Pinyon-Juniper community (Fig. 13).

Collections were made in January and July.

Foxella ignota should be further studied, especially in the Pinyon-Juniper community and the Artemisia associations found at higher elevations.

Diamanus montanus (Baker), 1895

In our surveys in Utah we found the Rock Squirrel to be a common host for this flea. Stark (1958) likewise reports this host preference. Literature records for other hosts indicate their habitats as foothills and median montane elevations. At the test site, *S. variegatus* was collected in the Pinyon-Juniper community on Rainier Mesa (Fig. 13). In our studies over the years, especially in Utah, the usual case was to find the host heavily infested, but at the test site only twelve fleas were collected. These were taken during April, May, and June.

Obviously a more extensive survey is needed, especially at higher elevations, to determine the extent of distribution and seasonal occurrence of this flea.

The flea is of public health importance in that it has been considered moderately effective in plague transmission (Stark, 1958).

Orchopeas sexdentatus (Rothschild), 1905

We consider this flea to be of the subspecies *O. sexdentatus agilis*. The taxonomic characters which have been used to distinguish the subspecies of *O. sexdentatus* are variously interpreted by different workers. A rather careful study needs to be made of this species over a wide geographical range. On the basis of literature descriptions and accompanying illustrations, our specimens are nearer *agilis* than a closely related form, *nevadensis*. Hubbard (1957) stated: "During 1938 this flea, *nevadensis*, was found to be a constant parasite on *Neotoma desertorum* (Wood Rat) in Clark County, Nevada, and Kane County, Utah."

Distribution. Hosts and their fleas were about equally distributed in Coleogyne and Larrea-Franseria communities. Other communities include Pinyon-Juniper, Salsola, Gravia-Lycium, and several mixed vegetative types (Fig. 15).

Host Associations. Four of 85 separate collections were from the Canyon Mouse. The re-

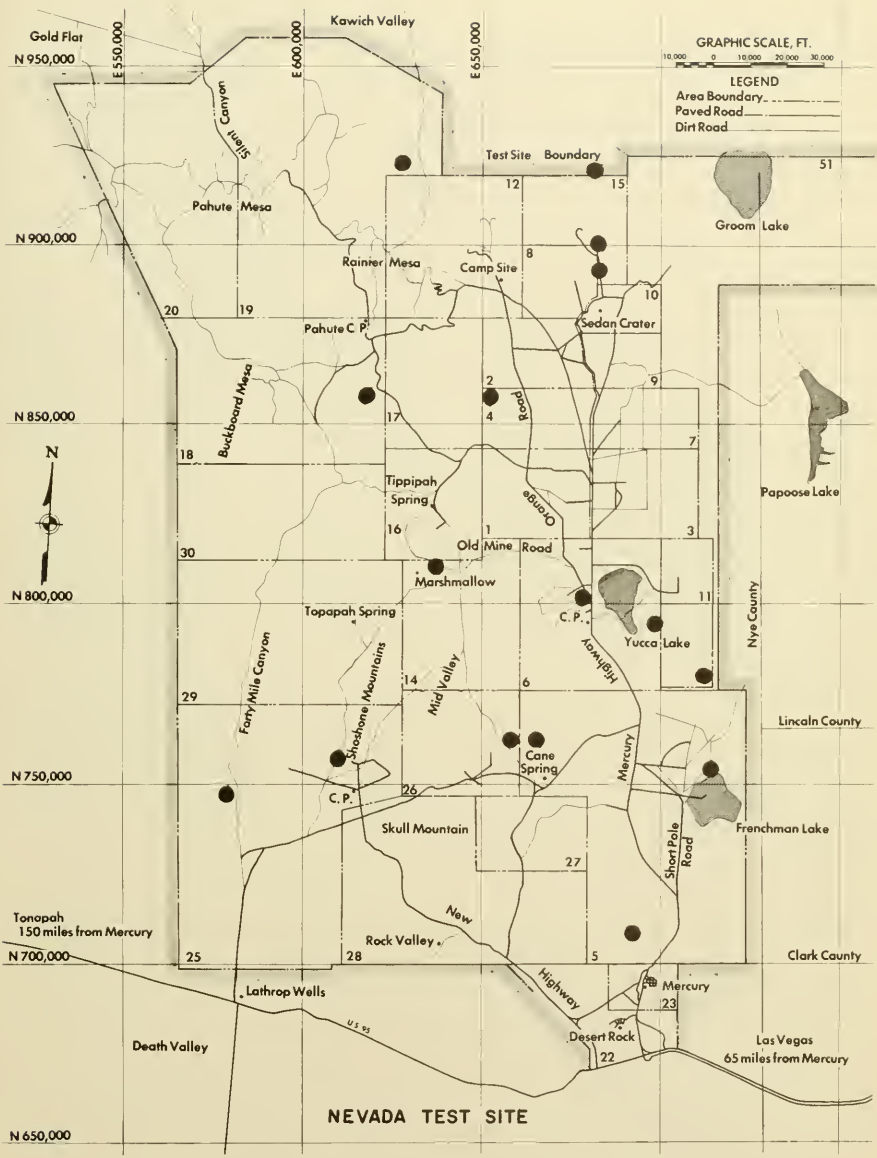

Fig. 15. Geographic distribution of *Orchopeas sexdentatus*

mainder were taken from the bodies of Desert Wood Rats.

Seasonal Occurrence. Twenty-three collections were made in January, 20 in November, 14 in December, 9 in October, and 9 in March. During February, April, June, and September, one to three encounters were made in each of the months.

Comments. Fleas of *O. sexdentatus* (no subspecific designation) have been found to harbor plague in nature and are considered efficient vectors of the disease (Eskey & Haas, 1939 & 1940).

During the 1965 summer surveys of wood rat habitats at the test site, we were impressed by the similarity of conditions encountered in surveys in other parts of the western United States. We found situations in which whole colonies of wood rats apparently had died. Nests and houses showed varying degrees of recent use, and dead bodies were found in the houses. As stated by Beck (1955), ". . . the disappearance of once abundant rodent populations has been too consistent to be happenstance. These extreme fluctuations in rodent populations may be due in part to man's interference with environmental conditions, or perhaps it is a reflection of inherent population rhythm. . . . It is possible that the almost, and, in some cases, complete disappearance is due to a disease agent and the vectors involved."

Monopsyllus wagneri (Baker), 1904

Our specimens are of the subspecies *M. wagneri wagneri*.

Distribution. All specimens were taken from hosts located along the foothills or at higher elevations. The majority were from the Pinyon-Juniper biotic community (Fig. 16).

Host Associations. In our extensive surveys in Utah and in surveys by other workers, specimens of *M. wagneri wagneri* are considered to be the most frequently collected fleas. They have been collected at elevations much higher than those of the desert valleys and lowlands at the test site. Most published data list the Deer Mouse as the preferred host. At the test site *P. maniculatus* has been found mainly at higher elevations in the Pinyon-Juniper community, and has provided some specimens of *M. wagneri wagneri*. Additional collections were made from the Pinyon Mouse, Southern Grasshopper Mouse, and Chisel-toothed Kangaroo Rat.

Seasonal Occurrence. Specimens were collected about equally during April and November. Two encounters were in July, and one each in August and October.

Comments. Extensive year-round surveys need to be made in the Pinyon-Juniper and Artemisia associations in the western and northwestern parts of the test site.

Monopsyllus eumolpi (Rothschild), 1905

Distribution. All specimens were collected in the north-central part of the test site in a Pinyon-Juniper community (Fig. 16).

Host Associations. This flea is commonly termed the "chipmunk" flea. Most collections at the test site were from the Cliff Chipmunk (*Eutamias dorsalis*). Additional fleas were taken from the Deer Mouse and Great Basin Pocket Mouse.

Seasonal Occurrence. Most collections were in April with minor occurrences in July and November.

Comments. Eighty-three specimens were collected. Although this may be considered comparatively few, all collections were in the Pinyon-Juniper community, a biotic situation where we have done relatively little survey work with the vertebrate fauna.

Malaraeus telchinum (Rothschild), 1905

Only two specimens of this species were collected at the test site. One was taken from the Chisel-toothed Kangaroo Rat, and the other from the Deer Mouse. Both were in a Pinyon-Juniper community during October and November (Fig. 16).

Malaraeus sinomus (Jordan), 1925

One of the principal characteristics used to separate *M. sinomus* from *M. eremicus* is the comparative length of the first metatarsal segment. In *eremicus* it is longer than the combined 2nd, 3rd, and 4th tarsal segments, whereas in *sinomus* it is shorter. The majority of our specimens fit *sinomus*, but there are borderline cases. Nevertheless, the structure of the ninth sternite of the male is unmistakably that of *M. sinomus*. It may be that specimens at the test site are at the meeting place of *eremicus* populations from the southeast and the *sinomus* populations from the north and southwest.

Distribution. Most collections at the test site were made along the foothills or in basins where

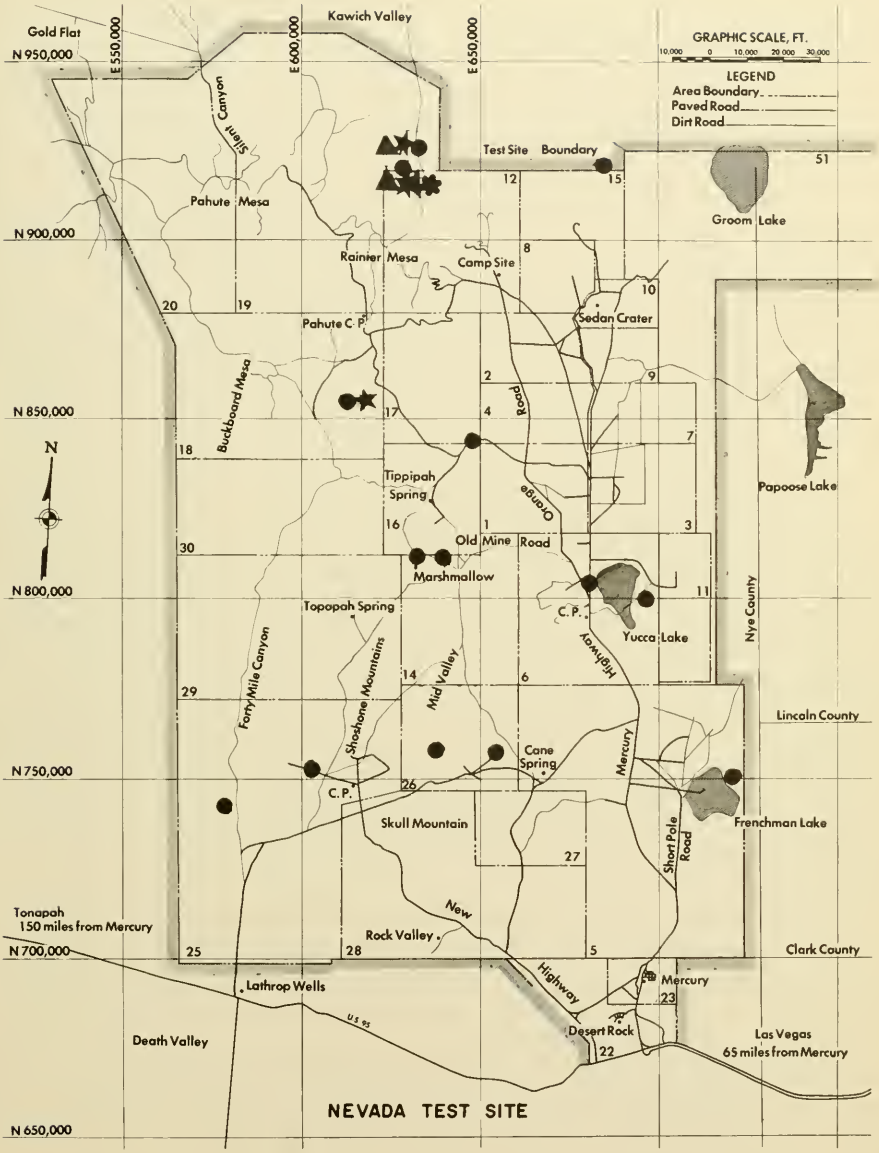

Fig. 16. Geographic distribution of *Monopsyllus wagneri* ★ *Malareus telchinum* ✤ *Monopsyllus eumolpi* ▲ and *Malareus sinomus* ●

the elevation is little higher than Frenchman and Yucca Flats. About equal encounters were made in the Larrea-Franseria and Coleogyne communities, plus occasional collections from Grayia-Lycium, Pinyon-Juniper, and mixed vegetative areas (Fig. 16).

Host Associations. Members of the genus *Peromyscus* are considered to be the preferred hosts. Most of our collections were from the Canyon Mouse, Deer Mouse, and Desert Wood Rat, with occasional collections from the White-tailed Antelope Squirrel, Southern Grasshopper Mouse, and Pinyon Mouse.

Seasonal Occurrence. Collections were made every month of the year except August and September, with most encounters in November, December, January, and February, successively. Only one or two encounters were made during other months of the year.

Comments. This flea is associated with hosts living along the foothills.

Malaraeus euphorbi (Rothschild), 1905

Only one collection of fleas of this species was made. Two males and six females were removed from a Deer Mouse in November from a Pinyon-Juniper community on Rainier Mesa (Fig. 17).

Amphipsylla neotomae Fox, 1940

A male and female specimen were taken from a Desert Wood Rat in the eastern end of Jackass Flats in a Larrea-Franseria community (Fig. 17).

Frank M. Prince (personal correspondence) indicated that *A. neotomae* should be listed as *Malaraeus neotomae*. Nothing has been published to this effect to date, so we are obligated to leave *neotomae* in its present generic allocation—*Amphipsylla*.

Odontopsyllus dentatus (Baker), 1904

Three fleas of this species were collected in April from Nuttall's Cottontail Rabbit from a Pinyon-Juniper community on Rainier Mesa (Fig. 17).

Fleas of this species, although not found in great numbers on the preferred hosts of several species of *Lepus* and *Sylvilagus* (jackrabbits and cottontails, respectively), are considered common. Many specimens of the Black-tailed Jackrabbit were collected during the period of this study, and large numbers of cottontails were also taken and checked for ectoparasites. Only one collection of *O. dentatus* was encountered. Fleas of this species likely are to be found on rabbits at higher elevations and northward into the Great Basin region. Collections of rabbits at higher elevations at the test site need to be made to corroborate this point of view. So far, most collections of rabbits have been made only in the valleys at the test site.

Peromyscopsylla hesperomys (Baker), 1904

According to keys and descriptions given by Johnson and Traub (1954), our specimens belong to the subspecies *P. hesperomys adelpha*.

Distribution. Most hosts and their fleas were taken along the foothills or at higher elevations. The biotic community most commonly represented was Coleogyne, followed by the mixed vegetative types, and to a lesser extent the Larrea-Franseria and Pinyon-Juniper communities (Fig. 17).

Host Associations. The Southern Grasshopper Mouse and Canyon Mouse were equally encountered with flea consortes. The next most often encountered was the Deer Mouse. Single encounters were made with the Pinyon Mouse, Great Basin Pocket Mouse, White-tailed Antelope Squirrel, and Southern Pocket Gopher.

Seasonal Occurrence. January, November, December, and April were the months of the year when most encounters were made. Single encounters were made in February, May, July, September, and October.

Comments. Records of this species emphasize the need for more intensive surveys along the foothills and at higher elevations of the test site.

According to Holdenried and Morlan (1955), fleas of this species have been found naturally infected with plague organisms.

Nycteridopsylla vancouverensis Wagner, 1936

Both Hubbard (1947) and Holland (1949) listed this flea under the generic name, *Eptescopsylla*. Following Hopkins and Rothschild (1953), we are using the generic name, *Nycteridopsylla*.

Five specimens were collected from a Western Pipistrelle Bat shot while flying in the vicinity of Tippipah Spring in November. This area is characterized as a mixed vegetative type of biotic community (Fig. 17).

The flea fauna of bats at the test site is relatively unknown, for few bats have been collected.

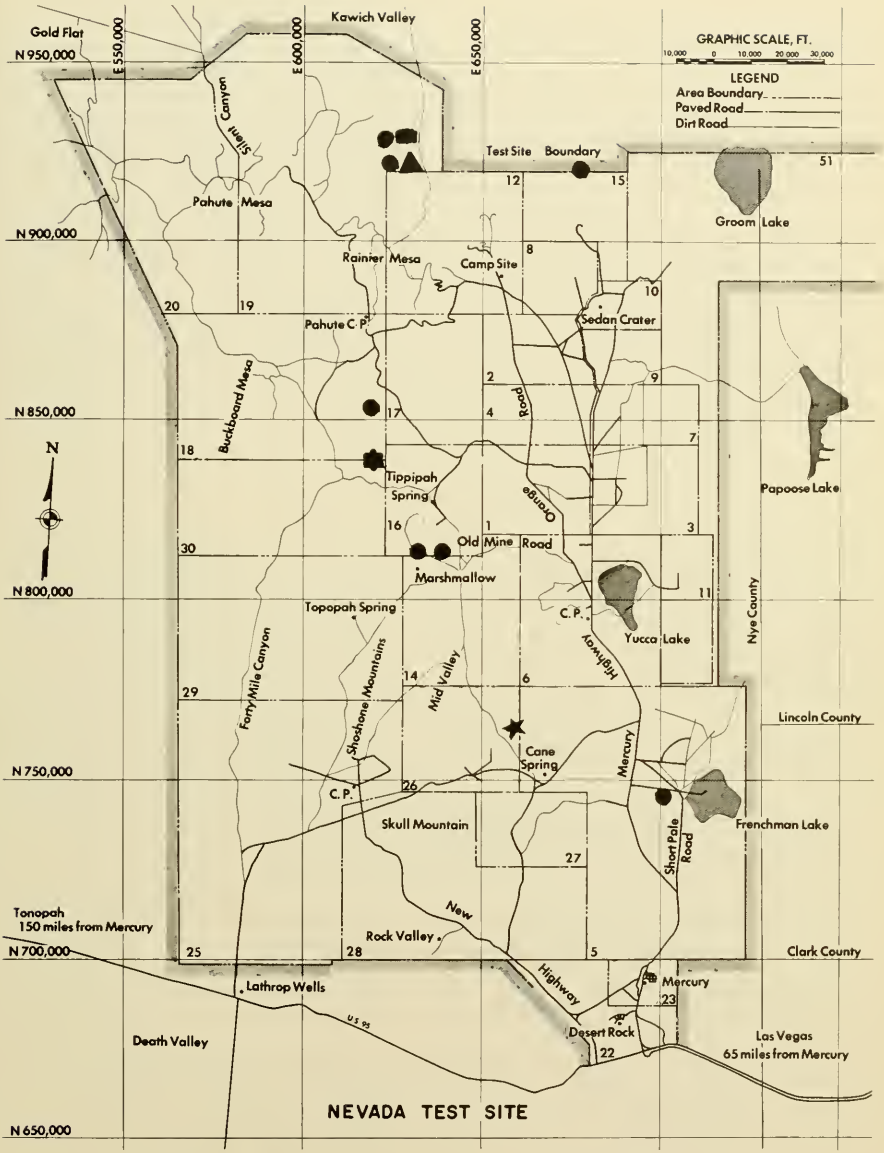

Fig. 17. Geographic distribution of *Malaraeus euphorbi* ▲ *Odontopsyllus dentatus* ■ *Nycteridopsylla (Eptescopsylla) vancouverensis* ✿ *Amphipsylla neotomae* ★ and *Peromyscopsylla hesperomys* ●

CONCLUSIONS

Naturally the flea fauna is best known from those host animals which have been most frequently collected. Kangaroo rats and White-tailed Antelope Squirrels were the animals most often collected. In those areas of the test site where studies were made over several years, a conspicuous reduction in numbers of fleas during the summer months was observed. Geographically, the fauna of Frenchman, Yucca, and Jackass Flats is best known, and animals of the foothills and mesas are least known.

Although thirty-three species are listed in this paper, this does not represent all that are expected to occur at the test site. The extensive stands of *Artemisia tridentata* in the western half of the test site are relatively unsurveyed biologically, and comparatively little has been done with the Pinyon-Juniper community on the mesas and elsewhere. To a certain extent this applies to the foothill environs. The test site does not contain high mountain ranges, and one would not expect to find hosts and their ectoparasites at the test site characteristic of high mountain elevations such as the Sheep Range to the east and the Charleston Mountains to the southeast.

About one-fourth of the species of fleas reported from the test site are from the Desert Wood Rat. Nevertheless, for the most part these records are not a result of year-round collecting in the various biotic communities where the rat is found. Such a study would assist in resolving some of the problems in the taxonomy of fleas of the genus *Malaraeus* and related groups. There is a junction of the Great Basin and the Mojave biota at the test site, and the fleas characteristic of these two provinces may demonstrate an unusual distribution pattern once it is known.

LITERATURE CITED

Allred, D. M., D E. Beck and C. D. Jorgensen. 1963b. Biotic communities of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., 2(2):1-53.

Allred, D. M., D E. Beck and C. D. Jorgensen. 1963b. Nevada Test Site study areas and specimen depositories. Brigham Young Univ. Sci. Bull., Biol. Ser., 2(4):1-15.

Beck, D E. 1955. Distributional studies of parasitic arthropods in Utah, determined as actual and potential vectors of Rocky Mountain spotted fever and plague, with notes on vector-host relationships. Brigham Young Univ. Sci. Bull., Biol. Ser., 1(1): 1-64.

Beck, D E., A. H. Barnum and L. Moore. 1953. Arthropod consortes found in the nests of *Neotoma cinerea acraia* (Ord) and *Neotoma lepida lepida* (Thomas). Proc. Utah Acad. Sci., Arts, and Letters, 30:43-52.

Beck, D E., D. M. Allred and E. P. Brinton. 1963. Ticks of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., 4(1):1-11.

Eskey, C. R. and V. H. Haas. 1939. Plague in the western part of the United States. Infection in rodents, experimental transmission of fleas and inoculation tests for infection. Public Health Reports, 54:1467-1481.

Eskey, C. R. and V. H. Haas. 1940. Plague in the western part of the United States. Public Health Bull., 254:1-83.

Goates, M. A. 1963. Mites on kangaroo rats at the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., 3(4):1-11.

Hall, E. R. (Ed.) 1957. Vernacular names of North American mammals. Univ. of Kansas Museum of Natural History, Miscellaneous Publication No. 14: 1-16.

Hayward, C. L., M. L. Killpack and G. L. Richards. 1963. Birds of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., 3(1):1-27.

Holdenried, R. and H. B. Morlan. 1955. Plague-infected fleas from northern New Mexico wild rodents. Jour. Infect. Dis., 96:133-137.

Holland, G. P. 1949. The siphonaptera of Canada. Science Service, Division of Entomology, Livestock Insects Laboratory, Pub. 817, Tech. Bull., 70:1-306.

Hopkins, G. H. E. and M. Rothschild. 1953. An illustrated catalogue of the Rothschild collection of fleas (Siphonaptera) in the British Museum (Natural History). Univ. Press, Cambridge, Vol. I.

Hopkins, G. H. E. and M. Rothschild. 1956. An illustrated catalogue of the Rothschild collection of fleas (Siphonaptera) in the British Museum (Natural History). Univ. Press, Cambridge, Vol. II.

Hopkins, G. H. E. and M. Rothschild. 1962. An illustrated catalogue of the Rothschild collection of fleas (Siphonaptera) in the British Museum (Natural History). Univ. Press, Cambridge, Vol. III.

Howell, F. J. 1955. A study of the aspectional variations of Siphonaptera associated with the nests of the Thomas Wood Rat, *Neotoma lepida lepida* Thomas. The Great Basin Nat., 15:(1-4):35-49.

Hubbard, C. A. 1947. Fleas of western North America. Iowa State College Press, Ames.

Johnson, P. T. and R. Traub. 1954. Revision of the flea genus *Peromyscopsylla*. Smithsonian Misc. Collections, 123(4):1-68.

Jorgensen, C. D. and C. L. Hayward. 1965. Mammals of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., 6(3):1-81.

McCoy, C. W. 1911. A new flea *Ctenophthalmus hciseri* spec. nov. (Siphonaptera). Entomol. News, 22:445-448.

Morlan, H. B. and F. M. Prince. 1954. Notes on the subfamily Rhadinopsyllinae Wagner, 1930 (Siphonaptera, Hystrichopsyllidae), and description of a new species, *Rhadinopsylla multidenticulatus*. Texas Reports on Biol. and Med., 12:1037-1046.

Prince, F. M. 1945. Descriptions of three new species of *Dactylopsylla* Jordan and one new subspecies of *Foxella* Wagner, with records of other species in the genera (Siphonaptera). Canadian Entomol., 77(1):15-20.

Stark, H. E. 1958. The Siphonaptera of Utah: Their taxonomy, distribution, host relations and medical importance. U. S. Dep. Health, Educ. and Welfare, Public Health Service, Commun. Dis. Center, Atlanta, Georgia.

Tanner, W. W. and C. D. Jorgensen. 1963. Reptiles of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., 3(3):1-31.

Traub, R. and V. J. Tipton. 1951. *Jordanopsylla allredi* a new genus and species of flea from Utah (Siphonaptera). J. Washington Acad. Sci., 41(8):264-270.

Wheeler, C. M. and J. R. Douglas. 1945. Sylvatic plague studies. V. The determination of vector efficiency. J. Infect. Dis., 77:1-12.

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Science Bulletin

ANTS OF THE NEVADA TEST SITE

by
ARTHUR C. COLE, JR.

BIOLOGICAL SERIES — VOLUME VII, NUMBER 3

JUNE 1966

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ANTS OF THE NEVADA TEST SITE[1]

by

Arthur C. Cole, Jr.[2]

INTRODUCTION

During the summer of 1962 I had the privilege of being stationed at the Nevada Test Site, as a part of Brigham Young University's research team, to make a study of the ants of the site. Previously I had identified extensive samples of ant populations that had been taken from can traps imbedded in the soil. The can traps served admirably in supplying me with nearly a complete list of the taxa occupying the site, and my field collections provided only a very few forms that had not appeared in the can samples. Thus, before I went to the site I had learned not only what taxa were there, but also which geographic areas and plant communities were involved.

Daily collections in the field provided many important data about the ants of the site and disclosed the presence of some taxa that were either new records for the state or species new to science. Three new species were represented; one of these (*Aphaenogaster megommatus* M. R. Smith) was described recently (Smith, 1963), one (*Veromessor smithi* Cole) was described subsequent to my studies on location at the site (Cole, 1963), and the other (*Stenamma* n. sp.) is described in this paper. Males of *Formica moki* Wheeler, which were found in a nest with associated workers, are described herein for the first time, as are also both sexual castes of *Aphaenogaster megommatus* M. R. Smith.

Although ants were represented to some extent in all plant communities of the test site, the disturbed Pinyon-Juniper community on Rainier Mesa supported the greatest number of taxa. Of the total of 52 taxa discovered at the test site, 28 were inhabitants of that community and 19 were found only there. Two conditions probably account for this distribution: (1) the natural condition of the habitat and plant community, and (2) the altered situation produced by the atomic detonations. The undisturbed Pinyon-Juniper community provides some degree of shade, a different type of soil texture, more soil moisture, and cooler diel temperatures than do the other communities of the test site. As a result of atomic detonations, the natural environment was considerably altered, apparently favorably so for many ant species. Most of the trees were killed by the atomic detonations, and surface rocks were disturbed considerably (Fig. 1). Unless otherwise stated, a disturbed community is one which has been affected by one or more atomic detonations.

For excellent accounts of the plant communities of the test site, the reader is referred to the publications in this series by Allred, *et al.* (1963) and Barnum (1964).

I am indebted especially to Dr. Dorald M. Allred and Dr. D Elden Beck, project supervisors, who invited me to participate in the project and were very helpful in providing excellent facilities for my use. I should like to express my appreciation to Merlin Killpack for his interest in my studies at the site and for his patience during our joint trips to collecting stations.

Glossary of Special Terms[3]

Cephalic index (CI). Head width X 100/head length.

Epinotum. The first abdominal segment fused with the thorax; the propodeum.

Eye length (EL). Maximum length of compound eye.

Eye width (EW). Maximum width of compound eye.

Funiculus. Portion of antenna distal to the scape.

Head length (HL). Length of head, in full face view, from anterior border of lateral clypeal lobes to the extreme posterior limits.

Head width (HW). Maximum width of head, excluding the eyes, in full face view.

Ocular index (OI). Eye length X 100/head length.

[1]B.Y.U.-A.E.C. Publication No. COO-1355-15. This work was supported under research contracts AT(11-1)-786 and AT(11-1)-1355 between the U.S. Atomic Energy Commission and Brigham Young University.

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[3]For glossaries of common ant terminology the reader is referred to publications by Smith (*Amer. Midland Nat.*, 37:626-91), Wheeler and Wheeler (*Ants of North Dakota*, 1963:305-8), and Cole (J. Tennessee Acad. Sci., 24:86-8).

Petiolar node length (PNL). Length of only the node of the petiole as measured in profile or dorsal view.

Petiolar node width (PNW). Maximum width of the petiolar node in dorsal view.

Postpetiolar length (PPL). Total length of the postpetiole in profile or dorsal view.

Scape. Basalmost segment of an antenna.

Scape index (SI). Scape length X 100 head width.

Scape length (SL). Length of the scape excluding the bulb at the base.

Thorax length (TL). Length of thorax, in profile view, from anterior margin of pronotum (excluding the collar) to the tip of the metasternal lobe.

Fig. 1. Disturbed Pinyon-Juniper community on Rainier Mesa.

FAMILY FORMICIDAE

A Key to the Subfamilies of FORMICIDAE for Identification of the Workers[1]

1. Abdominal pedicel consisting of two segments ..... Myrmicinae
   Abdominal pedicel consisting of one segment 2

2. Cloacal orifice distinctly circular and surrounded by a fringe of hairs ..... Formicinae
   Cloacal orifice slit-shaped, the hairs, when present, not forming an encircling fringe ..... Dolichoderinae

[1]Adapted from Creighton, Bull. Mus. Comp. Zool., 104:29, 1950.

Subfamily MYRMICINAE

A Key to the Genera of the Subfamily MYRMICINAE for the Identification of the Workers[4]

1. Postpetiole attached to dorsal surface of first gastric segment, the gaster flattened dorsally but much more convex vertically, acutely pointed behind ..... *Crematogaster*

   Postpetiole attached to anterior end of first gastric segment, the gaster about equally convex above and below and not notably pointed behind 2

2. Antennae with 10 segments, the last two forming a distinct club ..... *Solenopsis*

   Antennae with more than 10 segments, the club, if present, with more than two segments 3

3. Spurs on middle and hind tibiae distinctly pectinate 4

   Spurs on middle and hind tibiae not pectinate 5

4. Thoracic dorsum not impressed between the mesonotum and epinotum; psammophore present, but sometimes weak ..... *Pogonomyrmex*

   Thoracic dorsum impressed between the mesonotum and epinotum; psammophore absent ..... *Myrmica*

5. Epinotum unarmed, the basal face at the same level as the dorsum of the mesonotum ..... *Monomorium*

   Epinotum armed with spines or teeth 6

6. Workers dimorphic, with the head of the major disproportionally large ..... *Pheidole*

   Workers monomorphic 7

7. Thoracic dorsum with the mesoepinotal suture absent or very faint, epinotum not depressed well below level of mesonotum ..... *Leptothorax*

   Thoracic dorsum with the mesoepinotal suture prominent, epinotum depressed well below level of mesonotum 8

8. Clypeus with a pair of prominent, parallel, longitudinal carinae; eyes minute, set very low on sides of head ..... *Stenamma*

   Clypeus without a pair of prominent, parallel, longitudinal carinae; eyes notably larger, set higher on sides of head 9

9. Head quadrate, not notably narrower behind the eyes than in front of them; psammophore present ..... *Veromessor*

   Head longer than broad, much narrower behind the eyes than in front of them, the occipital corners more broadly rounded; psammophore absent ..... *Aphaenogaster*

Genus *Myrmica* Latreille

Myrmica emeryana tahoensis Wheeler

Colonies of *tahoensis*, the only member of its genus known from the test site, were restricted to the Pinyon-Juniper community and chiefly to that of Rainier Mesa. They were few and small, and were found under stones in the more shaded areas. The workers, docile and sluggish, can be distinguished from their close relatives elsewhere by the epinotal spines, which are distinctly bent downward, and by the reddish yellow thorax and blackish head and gaster.

Genus *Pogonomyrmex* Mayr

A Key to Species of the Genus *Pogonomyrmex* for Identification of the Workers

1. Mandible with six teeth; eyes placed decidedly below center of sides of head; clypeus with a prominent tooth-like projection in front of each antennal fossa; head, thorax, and petiolar node strongly rugo-reticulose; metasternal flanges strongly developed and prominently acute; psammophore weakly developed; small ants, length of largest workers less than 5.0 mm. *imberbiculus* Wheeler

   Mandible with seven teeth; eyes placed at approximately the center of the sides of the head, clypeus without prominent tooth-like projections; head, thorax, and petiolar node not strongly rugo-reticulose; metasternal flanges less well developed and more rounded; psammophore strongly developed; larger ants, length of largest workers notably greater than 5.0 mm. 2

2. Ventral surface of petiolar peduncle with a few, long, erect, downward-directed hairs; eyes small, weakly convex, not extending beyond sides of head with head in full-face view, the head length between the occipital corner and the mandibular insertion more than three times the greatest eye diameter *rugosus* Emery

   Ventral surface of petiolar peduncle without hairs; eyes notably larger, more strongly convex, extending well beyond sides of head with head in full-face view, the head length between the occipital corner and the mandibular insertion distinctly less than three times the greatest eye diameter 3

3. Interrugal spaces on head and thorax shining, free of sculpture or with fine punctures that do not obscure the shining surface; base of antennal scape weakly developed; epinotum without armature *californicus* (Buckley)

   Interrugal spaces on head and thorax opaque, densely and strongly punctate, the punctures (especially on the head) giving a beaded appearance; base of antennal scape strongly developed; epinotum with a pair of short to long spines 4

4. Basal-most mandibular tooth offset, meeting the basal mandibular margin at a pronounced angle; superior lobe of base of antennal scape truncate, the extreme base with a distinct carina extending to the apex of the superior lobe; interrugal punctures of sides of the pronotum not tending to obscure the rugae; dorsum of petiolar node irregularly rugose; base of dorsum of first segment of gaster strongly shining, at most only shagreened *occidentalis* (Cresson)

   Basal-most mandibular tooth not offset, meeting the basal mandibular margin evenly at a straight angle; superior lobe of base of antennal scape broadly rounded, the extreme base without a carina; interrugal punctures of sides of pronotum tending to obscure the rugae; dorsum of petiolar node with a number of rugae that are generally transverse and subparallel; base of dorsum of first segment of gaster usually densely and finely punctate, the surface subopaque or opaque *salinus* (Olsen)

Pogonomyrmex (*Pogonomyrmex*) *californicus* (Buckley)

I include, as a portion of this overall species population, the ant which has been known as *californicus estebanius*, for reasons that have been stated in my generic revision (Cole, 1965b). The latter has been distinguished from the typical, concolorous, ferrugineous red *californicus* by its bicolored body—the head and thorax being ferrugineous red and the gaster (as well as generally the petiole and postpetiole) black, wholly or in part. Both forms occur at the test site, often at the same stations and in the same nests.

Colonies were found abundantly in Grayia-Lycium and Salsola communities. They were less numerous in Larrea-Franseria, and rather sparse in Atriplex-Kochia, mixed, and Coleogyne communities. The nest of *californicus* is surmounted by a circular or semicircular crater of loose sand bearing a single, central entrance (Fig. 2). The worker may be distinguished from that of all

[3]Adapted from Cole (1965b). Validation of the names of the species is explained fully in the revision.

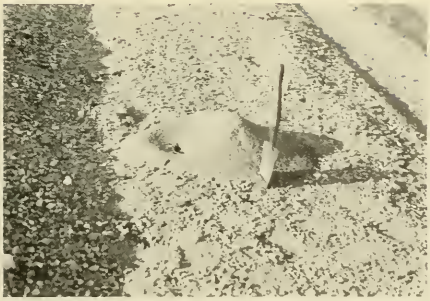

Fig. 2. Crater nest of *Pogonomyrmex californicus* in mixed community.

other species of *Pogonomyrmex* at the test site by a lack of epinotal armature. The sexual castes were found in nests in early and middle July.

Pogonomyrmex (*Pogonomyrmex*) *occidentalis* (Cresson)

Colonies of this species are characteristic of sagebrush (*Artemisia*) areas below the zone of Pinyon-Juniper. They contact the range of *P. salinus* in Pinyon-Juniper, but do not enter it. The characteristic gravel cones, or domes, surrounded by cleared areas and with basal entrances, predominate the landscape (Fig. 3).

The worker, which bears a close superficial resemblance to that of *salinus*, has the basalmost mandibular tooth offset from the margin, the superior lobe of the antennal scape base truncate, the petiolar and postpetiolar nodes without transverse rugae, and the dorsum of the base of the first gastric segment shining and without punctures. Far from being docile, the workers attack the intruder vigorously when a nest is disturbed and can inflict very painful stings.

Pogonomyrmex (*Pogonomyrmex*) *rugosus* Emery

This is the taxon that, together with certain of its variants, has been known as *barbatus rugosus* and which I have elevated to full species status in my unpublished revision of the genus *Pogonomyrmex* in North America (Cole, 1965b). Although colonies were most numerous in the Grayia-Lycium community, they occurred also

Fig. 3. Conical gravel mound of *Pogonomyrmex occidentalis* in an Artemisia community. Ruler is one foot in length.

in Atriplex-Kochia, Coleogyne, Larrea-Franseria, Salsola, and mixed communities. The nest superstructure consists of a very low gravel mound or disc with a large irregular central entrance (Fig. 4). The workers, which defend their nests with pugnacity, are the largest in the genus as represented at the test site. They are black, reddish black, or reddish brown in color, and can be distinguished from all other *Pogonomyrmex* of the site by the presence of a few erect hairs on the venter of the petiolar peduncle.

Pogonomyrmex (*Pogonomyrmex*) *salinus* Olsen

This species of harvester is one of the dominant ants of the Pinyon-Juniper community. In fact, it is pretty much of an "indicator species," for it is restricted to that community and therein replaces *P. occidentalis* at higher elevations. The nest is constructed in an open area between shrubs and is surrounded by a rather flat gravel bed which bears one or more saucer-like depressions with a central entrance (Fig. 5). It is surrounded by an area which has been cleared of plants by the ants.

The worker, which is rather closely allied to *P. occidentalis*, is characterized by its mandible, the basal-most tooth of which is not offset from the mandibular margin, the convex superior lobe of the base of the antennal scape, the generally transversely rugose dorsum of the petiole and postpetiole, and the usually strongly punctate and subopaque dorsal base of the first gastric segment. Unlike those of *occidentalis*, the workers are very docile ants and retreat to cover rather than attacking.

Pogonomyrmex (*Ephebomyrmex*) *imberbiculus* Wheeler

The diminutive, sluggish workers of this species form small, obscure colonies beneath stones. At the test site they were found in the Grayia-Lycium community. The only member of its subgenus known from the site, *imberbiculus* is distinctive in its small size (length 4-5 mm.), the pair of projections in front of the antennal fossae, the rugo-reticulose sculpture of head and thorax, and the very thick postpetiole. It is totally inoffensive in its behavior and retreats readily when disturbed.

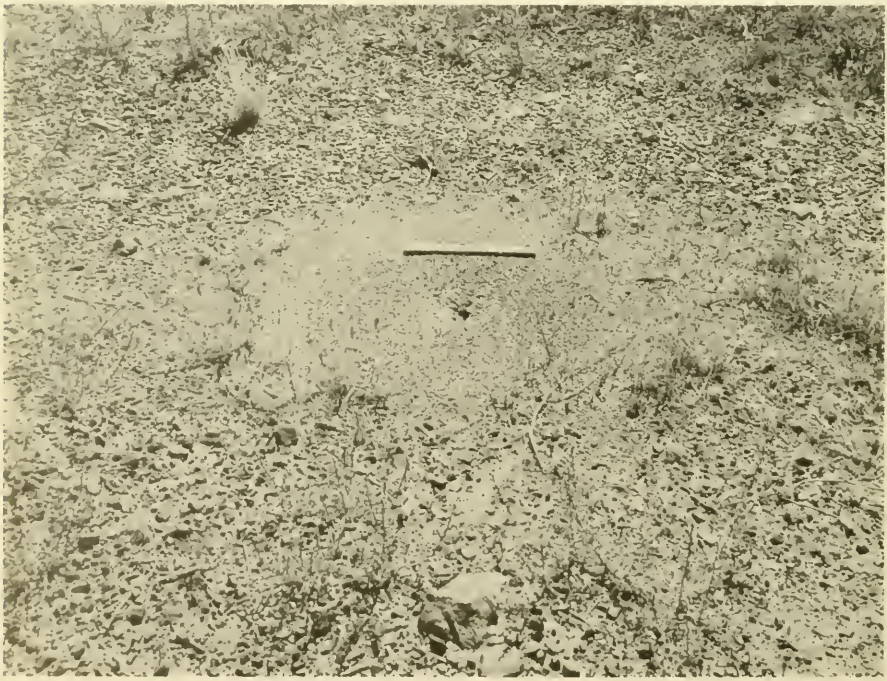

Fig. 4. Flat gravel disc of *Pogonomyrmex rugosus* in the Grayia-Lycium community. Ruler is one foot in length.

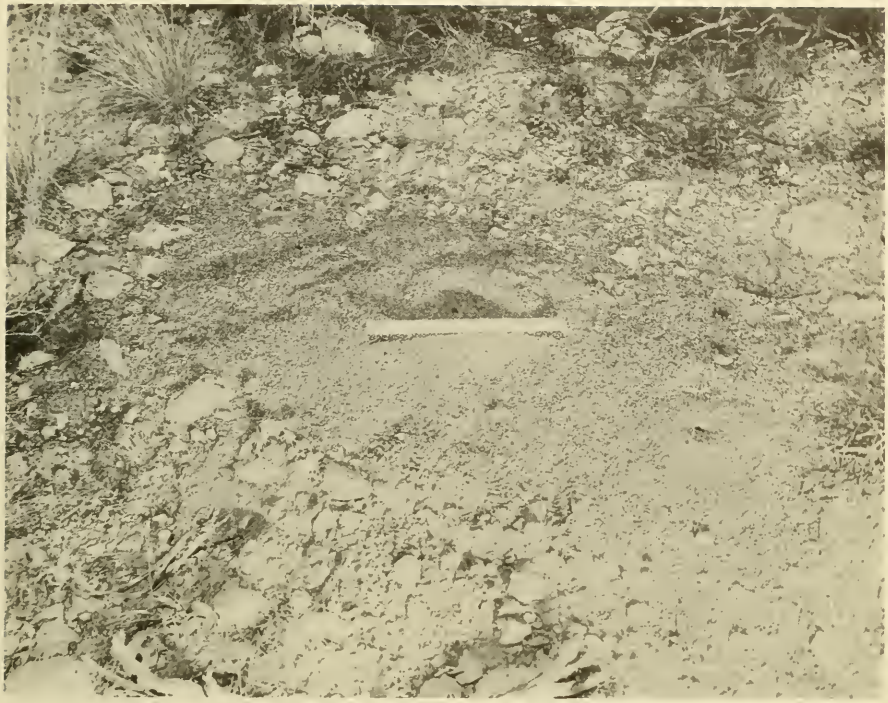

Fig. 5. Low gravel mound of *Pogonomyrmex salinus* in a Pinyon-Juniper community. Note the two saucer-shaped depressions and their central entrances. Ruler is one foot in length.

Genus *Stenamma* Westwood

Stenamma smithi, new species

Holotype, worker. HL 1.02 mm, HW 0.85 mm, CI 83.3, SL 0.08 mm, SI 94.1, EL 0.22 mm, EW 0.15 mm, OI 21.5, WL 1.22 mm, PNL 0.17 mm, PNW 0.22 mm, PPL 0.29 mm, PPW 0.31 mm.

Funicular segments two through six distinctly broader than long, last segment only slightly longer than combined lengths of the two preceding segments. Eye large, oval, with 12 ommatidia across its greatest diameter which is nearly equivalent to distance from lower eye margin to the mandibular insertion.

Contour of thoracic dorsum and of petiole and postpetiole as shown in Fig. 6; mesoepinotal impression pronounced, its greatest length 0.22 mm, its greatest depth 0.05 mm, bearing a distinct, transverse, median welt; declivity of epinotum long and steep; epinotal spines short but pronounced, acute apically and broad basally, directed rather strongly upward; petiolar peduncle rather short, its venter with a small, distinct, blunt process. Contour of petiolar and postpetiolar nodes, viewed from above, as shown in Fig. 7; petiolar node with a broad, blunt apex; postpetiolar node subspherical.

Sculpturing of head pronounced, the rugae rather coarse and wavy, especially laterally where they tend to form weak reticulations; front with subparallel, longitudinal striae; inter-

Fig. 6. Contour, in profile, of thoracic dorsum and of petiole and postpetiole of *Stenamma smithi*, n. sp. holotype.

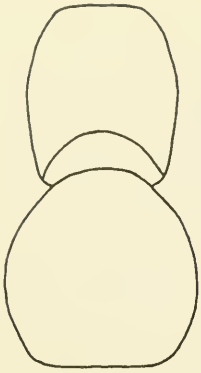

Fig. 7. Contours, viewed from above, of petiolar and postpetiolar nodes of *Stenamma smithi*, n. sp., holotype.

rugal spaces densely and finely punctate and subopaque. Pronotal rugae longitudinal, chiefly moderately coarse, somewhat wavy, widely and unevenly spaced; those of anterior border finer and transverse; interspaces shining, very finely and sparsely punctate. Base and sides of epinotum moderately rugose, the rugae longitudinal and unevenly spaced, the interspaces subopaque. Base of gaster with prominent, short, longitudinal rugulae with a maximum length of 0.086 mm. Gaster smooth, strongly shining.

Body with abundant, suberect to erect, golden hairs, those on the head notably shorter and denser than elsewhere. Hairs on legs mostly subappressed and reclinate, except on femora where they are distinctly suberect and erect.

Antennae, clypeus, genae, mandibles, thorax, legs, petiole, and postpetiole uniformly, medium ferrugineous red; frons, vertex, and occiput deeply and uniformly infuscated; dorsum of gaster a very deep, uniform, blackish brown.

Type locality. The holotype and 11 paratype workers were extracted from can samples taken on January 3, 5, 8, and 10, 1962, in B.Y.U. Study Area ECH of the test site. The nest was not found. I am pleased to name this interesting new species for Dr. M. R. Smith, my good friend and colleague, who recently revised the genus *Stenamma* in North America north of Mexico (Smith, 1957). I had sent the specimens to Dr. Smith for his inspection, and when he informed me that they appeared to represent a new species, I invited him to describe and name the population. However, inasmuch as he retired from his position at the U. S. National Museum before he could accomplish this, Dr. Smith kindly arranged for the return of the specimens to me.

Variation in paratype series. Variation among the specimens is remarkably slight. In a few of the workers the epinotal spines deviate somewhat in shape and size from those of the holotype. In some they are a little longer and less robust; in others they are a little shorter and more angular. The pronotal rugae in three specimens are rather arcuate and somewhat coarser. The number of ommatidia across the maximum diameter of the eye varies from 10 to 13. The pronotal width varies from 0.53 to 0.59 mm. Variations in other parts are as follows: HL 0.88 to 0.97 mm, HW 0.75 to 0.80 mm, CI 82.5 to 87.5, SL 0.73 to 0.77 mm, SI 93.7 to 96.3, EL 0.19 to 0.22 mm, EW 0.12 to 0.14 mm, OI 20.0 to 21.6, TL 1.07 to 1.09 mm, PNL 0.08 to 0.12 mm, PNW 0.17 to 0.21 mm, PPL 0.22 to 0.26 mm, PPW 0.27 to 0.31 mm.

Location of types. The holotype and one paratype will be deposited in the U. S. National Museum; other paratypes will be deposited in the Museum of Comparative Zoology and in the author's collection.

Affinities. In Smith's (1957, p. 142) revision of the genus the species keys to *brevicorne* (Mayr), an eastern species which ranges westward to Nebraska and Minnesota. It differs markedly from that species, however, especially in its greater body size and larger eyes, the differing dorsal contour of the thorax, the long declivity of the epinotum, and the conformation of the petiolar and postpetiolar nodes.

Genus *Aphaenogaster* Mayr

A Key to Species of the Genus *Aphaenogaster* for Identification of the Workers

1. Eye very large, strongly protuberant, with 18 to 20 facets in its greatest diameter, its lower border approximately the greatest ocular diameter from the mandibular articulation; body a sordid, pale, yellowish tan ..... *megommatus* M. R. Smith

   Eye notably smaller, with about 15 facets in its greatest diameter, its lower border about 1½ times the greatest ocular diameter from the mandibular articulation; body ferrugineous red ..... *boulderensis* M. R. Smith

Aphaenogaster boulderensis
M. R. Smith

This species was first described from workers collected on Horseshoe Island, Lake Mead, Boulder Dam (now Hoover Dam), Nevada. The distinctive worker is rather small (length 4.5 to 5.5 mm), very slender, and with strongly rounded posterior corners of the head and a rounded occipital border. The epinotal armature consists of faint tubercles. The body is a rather uniform, pale, ferrugineous red, with the gaster sometimes slightly darker.

No nest was found at the test site. Two workers were taken from soil cans in mixed vegetation in October. The ants probably nest beneath stones and form small colonies. Apparently *boulderensis* is poorly represented at the test site. It may indeed be a rare ant anywhere.

Aphaenogaster megommatus
M. R. Smith

This species was described recently (Smith, 1963) from workers collected in Nevada, Arizona, California, and Oregon. Although no nest was found at the test site, the ants rather commonly appeared in can traps from areas of Larrea, Larrea-Franseria, and Grayia-Lycium.

A. megommatus is a crepuscular and nocturnal forager. The worker is readily recognizable by its pale color, extraordinarily large, black eyes, and long, slender antennal scapes. Body length varies from 4.0 to 5.5 mm.

The previously undescribed sexual castes are described as follows:

Male. HL 0.71 to 0.88 mm, HW 0.63 to 0.70 mm, CI 112.7 to 125.7, SL 0.31 to 0.34 mm, SI 48.5 to 48.9, EL 0.48 to 0.68 mm, EW 0.37 to 0.43 mm, OI 60.1 to 77.3, TL 1.99 to 2.14 mm, PNL 0.14 to 0.19 mm, PNW 0.22 to 0.24 mm, PPL 0.26 to 0.31 mm, PPW 0.34 to 0.41 mm.

Head distinctly longer than broad; eyes very large; maximum width of head across the eyes 0.82 to 0.88 mm; antennal scape short, its length less than the combined lengths of first two funicular segments; anterior border of median lobe of clypeus with a shallow but distinct notch. Epinotal armature consisting of a pair of short, blunt, tubercles; petiolar and postpetiolar contours as illustrated in Fig. 8; petiolar node not pronounced, its apex broadly convex. Contour of paramere of genitalia as shown in Fig. 9, of volsella as in Fig. 10, and of aedeagus as in Fig. 11; abdominal sternite IX as shown in Fig. 12.

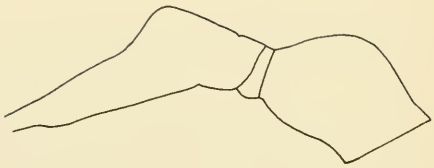

Fig. 8. Contours, in profile view, of petiole and postpetiole of a male *Aphaenogaster megommatus*.

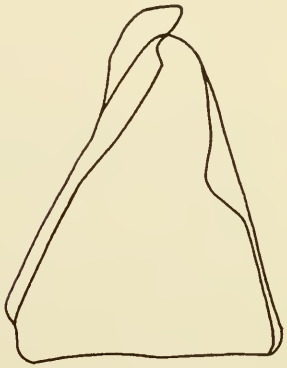

Fig. 9. Contour of paramere of a male *Aphaenogaster megommatus*.

Fig. 10. Volsella of a male *Aphaenogaster megommatus*.

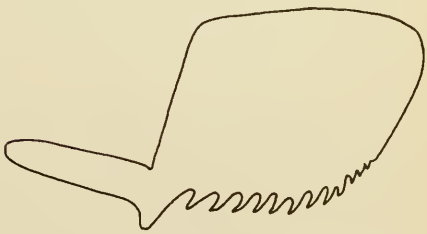

Fig. 11. Aedeagus of a male *Aphaenogaster megommatus*.

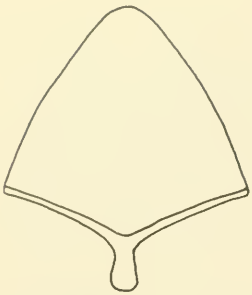

Fig. 12. Abdominal sternite IX of a male *Aphaenogaster megommatus.*

Head very densely and finely punctate, subopaque; thorax faintly and finely punctate, the punctures extremely delicate, the integument translucent and somewhat shining; gaster prominently, densely, and finely shagreened, the surface highly polished.

Hairs on head, thorax, petiole, and postpetiole sparse, rather long, erect and suberect, of unequal length, pointed, slender, and golden, especially delicate on scutum; a few suberect hairs on occipital corners of head; numerous on gular region; on the thorax most abundant on tuberculate areas of epinotum; unusually long and sparse on petiolar and postpetiolar nodes; rather long, scattered, delicate, pointed, erect, and suberect on gaster.

Thorax, appendages, petiole, postpetiole, gaster, and anterior half of head a rather uniform, dusky yellow; posterior half of head strongly infuscated, especially deeply within the ocellar triangle; mandibular teeth deep reddish brown; eyes black.

Female. HL 1.37 to 1.52 mm, HW 1.25 to 1.29 mm, CI 82.2 to 91.5, SL 1.56 to 1.60 mm, SI 124.0 to 124.8, EL 0.49 to 0.53 mm, EW 0.38 to 0.46 mm, OI 34.9 to 37.6, TL 2.67 to 2.81 mm, PNL 0.27 to 0.34 mm, PNW 0.38 to 0.42 mm, PPL 0.38 to 0.46 mm, PPW 0.53 to 0.65 mm.

Head notably longer than wide, occipital corners rather broadly and evenly rounded; extreme occipital margin with a low, narrow, transverse carina; eyes subovate, very large, their greatest diameter approximately one-third more than distance from lower eye margin to mandibular articulation, with 20 to 23 facets in their greatest diameter; maximum head width across the eyes 1.41 to 1.52 mm; antennal scapes

Fig. 13. Contour, in profile, of thoracic dorsum and of petiole and postpetiole of a female *Aphaenogaster megommatus.*

long, in repose extending well beyond posterior corners of head.

Contours of thorax, petiole, and postpetiole as shown in Fig. 13; epinotal declivity short and very steep; epinotal spines robust, broad, finger-like, bluntly rounded apically, flattened laterally, directed strongly backward; petiolar peduncle with a rather well-developed, longitudinal keel; petiolar node broadly and evenly rounded apically; postpetiole with a small, prominent, sharp, anteroventral, downwardly directed spine, the node with a long anterior declivity and a short posterior declivity. Contours of petiolar and postpetiolar nodes, viewed from above, as shown in Fig. 14; apex of petiolar node broadly truncate, notably narrower than the base; postpetiolar node considerably broader than long, the sides rather strongly convex.

Head prominently, unevenly, longitudinally rugulose, the interspaces somewhat shining and with dense and very delicate punctures; mandibles finely, longitudinally striate, densely and finely punctulate, and subopaque; frontal area

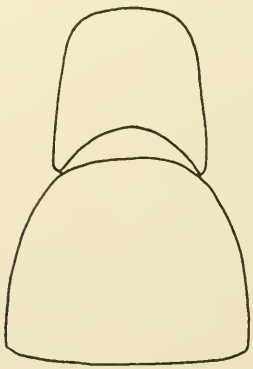

Fig. 14. Contours, viewed from above, of petiole and postpetiole of a female *Aphaenogaster megommatus.*

with three or four longitudinal carinae. Pronotum, scutum, and scutellum mostly smooth and strongly shining; epinotum transversely, unevenly rugulose, the interspaces finely and densely punctulate and subopaque; petiolar and postpetiolar nodes subopaque, finely and densely punctulate, and with sparse, irregular rugulae. Gaster moderately shining, densely and finely shagreened.

Hairs yellow, moderately abundant, and scattered; shorter, less delicate, and more blunt on scutum than on head and scutellum; sparse, rather long, and robust on epinotum, petiole, and postpetiole.

Body and appendages mostly a rather uniform, sordid light brown; scutum sometimes notably infuscated; eyes jet black; mandibular teeth deep reddish brown.

These descriptions are based upon the following specimens: Last Chance Canyon, El Paso Mts., Kern Co., Calif., July 10, 1964, R. R. Snelling leg (6♂, 4♀); 7 miles S. of Benton, Mono Co., Calif., August 9, 1962, R. R. Snelling leg (2♂, 4♀); Las Vegas, Nev., July 22, 1963, collector unknown (1♂); Nevada Test Site, can traps, July 28, 1961 (1 nest queen), July 1, 1962 (1♂), August 12, 1962 (1 nest queen), August 19, 1963 (1♀), August 25, 1963 (1 nest queen).

Genus *Veromessor* Forel

A Key to Species of the Genus *Veromessor* for Identification of the Workers[6]

1. Middle of anterior border of clypeus with a prominent projection; eye with a distinct anteroventral angle; color piceous brown to black; strongly polymorphic; forage in files ..... *pergandei* Emery

   Middle of anterior border of clypeus without a projection; eye without a distinct anteroventral angle; color pale brownish yellow to deep ferrugineous brown; not strongly polymorphic; forage singly 2

2. Head strongly, longitudinally, and rather evenly rugose, the rugae extending into the occipital region; eye small (OI 22), the distance from its posterior margin to the occipital margin greater than 1½ times its maximum diameter; epinotal spines very long, about 1½ times the distance between their bases; nests generally beneath stones in compact gravelly soil; diurnal; length 6.29 to 6.87 mm; thoracic profile as shown in Fig. 16C; base of antennal scape flattened, broader than apex; color a rather uniform, deep, ferrugineous brown ..... *lobognathus* (Andrews)

   Head not strongly rugose, the rugae not extending into the occipital region; eye large (OI 30 to 31), the distance from its posterior margin to the occipital margin no greater than or notably less than 1½ times its maximum diameter; epinotal spines shorter, no longer than the distance between their bases; nests in open and surmounted by craters; crepuscular or nocturnal; length 3.61 to 5.86 mm 3

3. Occipital region of head shining and faintly shagreened; rugae around antennal fossae concentric; maximum diameter of eye subequal to distance from posterior margin of eye to occipital margin; SI 87; base of scape narrower than apex and not flattened, the dilation reduced, involving only the extreme base, and meeting the shaft at strong angles; thoracic contour as shown in Fig. 16B; epinotal spines notably shorter than distance between their bases; apex of petiolar node acute; head, thorax, petiole, and postpetiole brownish yellow; gaster darker; length 3.61 to 5.86 mm; nocturnal ..... *lariversi* M. R. Smith

   Occipital region of head subopaque, densely and finely punctate; rugae around antennal fossae not concentric; distance from posterior margin of eye to occipital margin of head about 1 1/6 times maximum diameter of eye; SI 96; base of scape flattened, broader than apex, the dilation involving more of the shaft and meeting it at weaker angles; thoracic contour as shown in Fig. 16A; length of epinotal spines and their interbasal distance subequal; apex of petiolar node broadly convex; head, thorax, petiole, and postpetiole medium reddish brown, gaster slightly darker; length 5.70 to 5.86 mm; crepuscular ..... *smithi* Cole

[6]Adapted from Cole (1963, pp. 681-2).

Veromessor lariversi M. R. Smith

Although generally sympatric with *V. smithi* and occupying the same stations, *lariversi* was relatively uncommon. Most colonies were in sandy areas with mixed vegetation. Nests occurred very sparsely, however, in Grayia-Lycium, Salsola, and Coleogyne communities. Each nest was surmounted by one or two circular craters of sand, three inches or less in diameter, and marked by a rather large, irregular entrance (Fig. 15). Maximum depth of a nest was two feet, well above the hardpan layer. The workers are nocturnal foragers, as their pale color and large eyes would seem to indicate. Winged males and females, few in number, were in some of the nests between July 4 and 27.

Workers of *lariversi* can be distinguished easily from other species of *Veromessor* at the test site by their brownish yellow head, thorax, petiole, postpetiole, and their rather contrastingly darker gaster; and by the shining occipital region of the head, the large eyes, the very short epinotal spines, and the acute apex of the petiolar node. The dorsal contours of the thorax, petiole, and postpetiole are shown in Fig. 16B. For further information on this species the reader is referred to papers by Smith (1951) and Cole (1955, 1963).

Veromessor lobognathus (Andrews)

Probably more colonies of this species have been found at the test site than at all other localities combined. Although *lobognathus* had been considered to be a rare ant, it has become evident that it can be a common occupant of certain stations such as that on Rainier Mesa in disturbed Pinyon-Juniper. First described from Colorado (Andrews, 1916), it was rediscovered there by Gregg (1955) and near Ely, Nevada, by Cole (Gregg, *loc. cit.*), and subsequently in North Dakota and South Dakota by Wheeler and Wheeler (1956, 1959, 1965). At the test site the nests were largely confined to Rainier Mesa and were restricted to Pinyon-Juniper areas where they were sympatric with *Pogonomyrmex salinus* Olsen—a species whose workers remarkably resemble superficially those of *lobognathus*. On the mesa I excavated and

Fig. 15. Mound of *Veromessor lariversi* in a mixed plant community. Ruler is six inches in length.

studied 47 nests of *lobognathus* and located 11 others which were not disturbed. The colonies were very populous and lived beneath large rocks, some of which were deeply and strongly embedded in the soil and banked peripherally with a light coating of gravel. One nest opened into a gravel crater beside the covering rock.

The workers moved rapidly and agilely when a nest was opened. They did not attack the intruder. Distinct and perpetual stridulation was heard. During late June and early July numerous males and females were in the nests. *V. lobognathus* seems to be one of the most abundant and successful components of the ant fauna on Rainier Mesa.

The worker can be identified easily by its strong, superficial resemblance to *Pogonomyrmex occidentalis* and *salinus;* its deep, ferruginous brown color; its small eyes; and its very long epinotal spines. The contours of the thorax, petiole, and postpetiole, in profile, are illustrated in Fig. 16C.

Veromessor pergandei Emery

Probably by far the glossiest black ant of the low desert, *pergandei* is the dominant species of the Larrea community where it is able to flourish under extremely xeric conditions. It is a diurnal forager which can remain active during periods of intense heat. The long trails of streaming, black workers represent a characteristic pattern of extranidal activity. The nests, which are in exposed soil, are surmounted by low, semicircular or circular craters (sometimes multiple) of sand (Fig. 17) and are often cov-

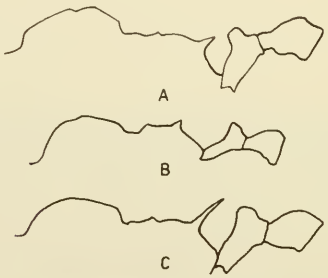

Fig. 16. Contour of thoracic dorsum and of petiole and postpetiole. A. *Veromessor smithi;* B. *V. lariversi;* C. *V. lobognathus.* Worker caste.

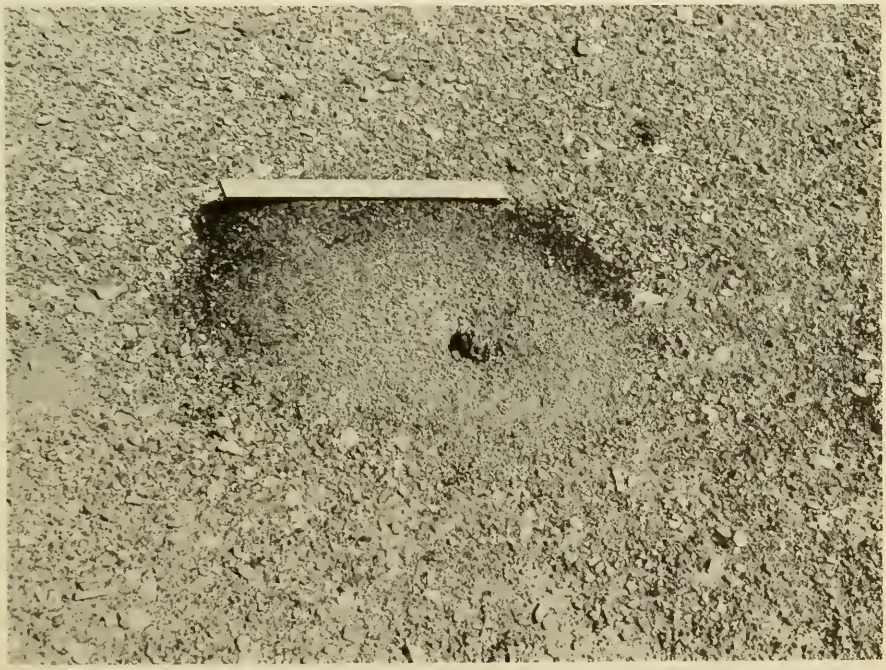

Fig. 17. Mound of *Veromessor pergandei* in a Larrea community. Ruler is one foot in length.

ered with a dense layer of chaff from harvested seeds. The workers are strongly polymorphic. This characteristic, the concolorous black body, and the presence of a prominent projection on the middle of the anterior border of the clypeus will serve to separate the species from all others in the genus at the test site and elsewhere.

Veromessor smithi Cole

This species was described from numerous specimens of all castes collected at the test site (Cole, 1963). Most nests were in the *Coleogyne* area at the foot of Rainier Mesa, where they were numerous, but one nest was observed in open, sandy desert with mixed vegetation. They occurred in fully exposed areas between plants, and each was marked by a small, circular crater of soil about five inches in diameter (Fig. 18). The timid, sluggish workers appear to be crepuscular foragers. They can be recognized by the medium, reddish brown body color, the large eyes, the punctate and subopaque occiput, the epinotal spines of medium length, and the distinctive thoracic contour and broadly subtruncate petiolar node (Fig. 16A).

Winged castes appeared abundantly in the nests between July 4 and 27. Mating flights were not observed.

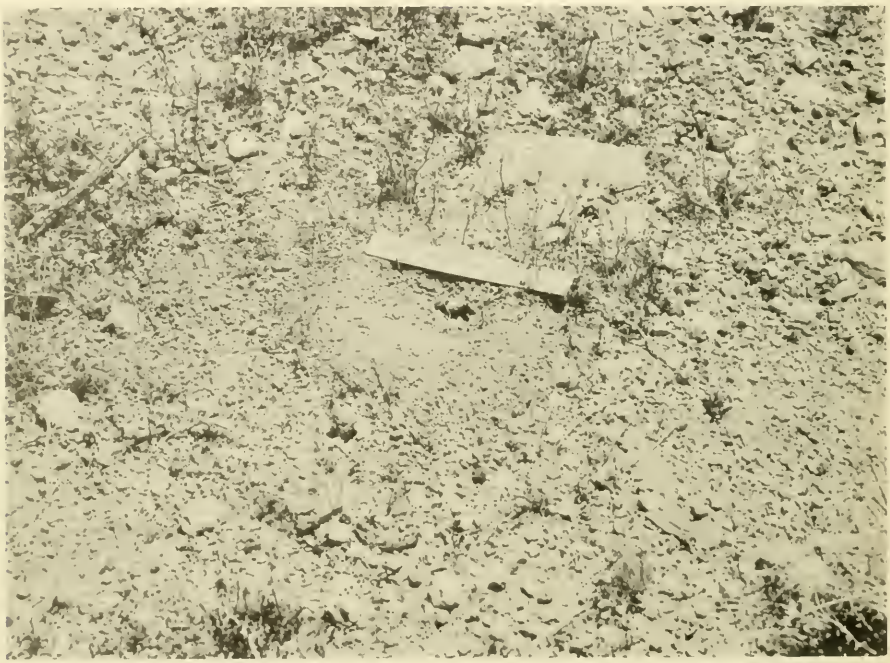

Fig. 18. Mound of *Veromessor smithi* in a Coleogyne community. Ruler is six inches in length.

Genus *Pheidole* Westwood

A Key to Species of the Genus *Pheidole* for Identification of the Workers

1. Antennal scape of major surpassing the occipital corner; large ants, length of major 4.5 to 5.0 mm, of minor 3.0 to 3.5 mm ..... *desertorum* Wheeler

   Antennal scape of major not reaching the occipital corner; smaller ants, length of major less than 4.5 mm, of minor less than 2.5 mm 2

2. Major with transverse occipital striae which are confined chiefly to the top of the occiput ..... *pilifera coloradensis* Emery

Occiput of major without transverse striae or rugae 3

3. Epinotum of the minor bearing a pair of thick, bluntly rounded spines of approximately the same diameter throughout; promesonotal suture of the major and minor distinct; inquilines in nests of *P. pilifera coloradensis* . . . . . *inquilina* (Wheeler)

Epinotal spines of the minor sharp, tapered, and more slender; promesonotal suture of the major and minor faint or absent; not inquilines 4

4. Anterior clypeal margin of the major sinuate; pronotum smooth and shining; basal face of epinotum somewhat shining . . . . . *bicarinata paiute* Gregg

Anterior clypeal margin of the major bluntly bidentate; pronotum punctate and usually with transverse striae or rugae; basal face of epinotum opaque . . . . *bicarinata vinelandica* Forel[7]

Pheidole bicarinata paiute Gregg

The types of this recently described subspecies (Gregg, 1958) came from Goldfield, Nevada, at an elevation of 5,800 feet. Colonies were numerous at the test site in areas of Grayia-Lycium, Larrea-Franseria, Coleogyne, and Atriplex-Kochia. The nests were beneath stones. Majors were numerous in a colony, and the ratio between them and the minors seems to be unusually great for a *Pheidole*. The docile, small, brown majors, with a body length of 4.0 to 4.5 mm, are readily distinguishable by the broadly sinuate anterior margin of the clypeus, the apunctate and strongly shining pronotum, and the strong rugae enclosing laterally the rather shining but distinctly punctate basal surface of the epinotum.

Pheidole desertorum Wheeler

A common occupant of our southwestern deserts, *desertorum* was most prevalent at the test site in Grayia-Lycium and mixed plant communities. It occurred to a decidely more limited extent in Coleogyne, Larrea-Franseria, and Salsola areas. Nests were beneath the larger stones. Colonies were generally large and the occupants very active and pugnacious. The majors, which attain a body length of about 4.5 to 5.0 mm, can be identified easily by their long antennal scapes and by their reddish yellow color.

Pheidole inquilina (Wheeler)

At the test site this especially interesting species is an inquiline in nests of *Pheidole pilifera coloradensis* Emery. Described as the type species of the monotypic genus *Epipheidole* by Wheeler (1903, p. 664), this species was recently transferred to the genus *Pheidole* by Cole (1965a) who, at the test site, discovered the unknown soldier caste and rediscovered the worker, and subsequently showed that they are representative of *Pheidole*, not a genus of their own.

Nests of the host ants, which were confined to disturbed Pinyon-Juniper on Rainier Mesa, were under loose stones. A total of only one soldier and two workers of *inquilina* was found, indicating the rarity of these castes, but several alate males and both alate and dealate females of the inquiline were in the nests. The sexes, as well as the small workers, can be recognized by their finger-shaped epinotal spines. The soldier (major worker) shows close affinities to that of *coloradensis*, the host ant, but it is of notably smaller stature, the occiput is smooth and shining and lacks the transverse rugae or striae that are characteristic of the host soldier, the dorsal contours of the thorax, petiole, and postpetiole are distinctively different, and the body color is much lighter. Cole (*ibid.*, p. 174, figs. 1, 2) has compared the contours, in profile, of the thorax, petiole, and postpetiole of the soldiers in the two taxa.

The discovery of *inquilina* at the test site has extended considerably westward its range which included previously only Nebraska and Colorado.

Pheidole pilifera coloradensis Emery

Nests of this taxon were found only beneath rather large stones in disturbed Pinyon-Juniper on Rainier Mesa. Colonies were rather numerous. Winged forms were in some of the nests between June 22 and July 4, 1962.

The timid, dark reddish brown soldiers can be recognized easily by their transversely rugulose or striate occiput and the presence of well-developed lateral connules on the postpetiole.

[7]Although this ant has not been taken at the test site, I have included it in the key because it has been collected from adjoining areas and will probably be found eventually at the site

Genus *Crematogaster* Lund

A Key to Species of the Genus *Crematogaster* for Identification of the Workers

1. Dorsum of thorax without erect hairs; promesonotum densely punctate, the punctures largely replacing the rugae ..... *depilis* Wheeler

   Dorsum of thorax with one, long, erect hair at each humeral angle; rugae on dorsum of promesonotum coarse and vermiculate, the interrugal punctures prominent, the surface opaque ..... *coarctata vermiculata* Emery

Crematogaster coarctata vermiculata Emery

Although I have assigned all pertinent collections to *vermiculata*, the test site appears to be in a region of transition between *vermiculata* and *coarctata*, inasmuch as some of the workers seem to represent intergrades of the two populations. Problems of this kind will have to be resolved by a generic revision following an inspection of large series of ants from all parts of their range.

Nests at the test site were chiefly in open soil, but in Pinyon-Juniper on Rainier Mesa they were found sparsely under stones. Although being most numerous in the Larrea-Franseria community, they occurred also in considerable numbers in Atriplex-Kochia and less abundantly in both mixed and Grayia-Lycium communities. The characters used in the key will serve adequately to separate the two species of *Crematogaster* known from the test site. Males and females were found in nests on Rainier Mesa on July 28.

Crematogaster depilis Wheeler

Strangely and apparently absent from the Pinyon-Juniper community, colonies of *depilis* were most numerous in the Larrea-Franseria and mixed communities. The nests were in open areas between shrubs or at the bases of the plants. Colonies appeared not to be so populous as those of *vermiculata*. The workers can be recognized by the lack of hairs on the pronotum and by their generally brown color.

Genus *Monomorium* Mayr

Monomorium minimum (Buckley)

This minute, black species nests beneath stones chiefly in the Coleogyne and mixed communities, although a few scattered colonies were found in the Pinyon-Juniper community of Rainier Mesa. The worker is readily recognizable by its small size, black color, smooth and highly polished body, and the unarmed epinotum. The populous colonies contained very active workers and multiple queens. The sexual castes were not found.

Genus *Solenopsis* Westwood

A Key to Species of the Genus *Solenopsis* for Identification of the Workers[3]

1. Second and usually the third funicular segment of antennae at least 1½ times as long as broad; workers polymorphic 2

   Second and third funicular segment of antennae at most only slightly longer than broad, usually broader than long; workers very small, not polymorphic, their nests frequently in those of other ants 3

2. Eyes of major with no more than 50 facets, those of minor with about 20 facets; front of head of major with only a few widely scattered punctures; dorsum of epinotum of minor, in lateral view, rather strongly convex; body a concolorous golden yellow ..... *aurea* Wheeler

   Eyes of major with 70 to 80 facets, those of minor with about 50 facets; front of head of major with numerous punctures; dorsum of epinotum of minor, in lateral view, weakly and broadly convex; head and thorax yellow to red, gaster usually notably darker. ..... *xyloni* McCook

[3]Adapted from Creighton (*Ibid.*, pp. 228-30) and Snelling, California Dep. Agr. Occasional Papers No. 3, 1963, 3-5.

3. Punctures on head dense, small, distinct, clearly greater in diameter than the hairs which arise from them ..... *salina* Wheeler

   Punctures on head sparser, smaller, often visible only under high magnification, only a little larger than the hairs which arise from them ..... *molesta validiuscula* (Emery)

Solenopsis aurea Wheeler

Nests of this species were in open soil of the Coleogyne and Grayia-Lycium communities, and were more representative of the former. The colonies were small and few. The key characters will suffice for recognition of this ant. The uniformly golden yellow color of the body in all workers is a characteristic feature.

Solenopsis molesta validiuscula (Emery)

This minute (length 1.8 to 2.0 mm), brownish yellow species nests independently or in colonies of other ants. Most colonies were found in Pinyon-Juniper, and especially in nests of *Pheidole pilifera coloradensis*, but the species occupied also, to a very limited degree, the Grayia-Lycium and Larrea-Franseria communities.

Solenopsis salina Wheeler

Three colonies of what probably represents this species were found beneath stones in the disturbed Pinyon-Juniper community of Rainier Mesa. A species difficult to separate from *molesta validiuscula*, *salina* has numerous cephalic punctures that are of greater diameter than the hairs which rise from them, and a distinct ventral tooth on the venter of the petiolar peduncle.

Solenopsis xyloni McCook

The strongly polymorphic workers of *xyloni* were found infrequently in the Larrea-Franseria community where they nest at the base of shrubs. The minor workers are considerably darker than the larger workers.

Genus *Leptothorax* Mayr

A Key to Species of the Genus *Leptothorax* for Identification of the Workers

1. Antennal scape in repose failing to reach the occipital margin by an amount twice as great as its greatest thickness; epinotal spines reduced to short, broad angles; thoracic dorsum densely and finely punctate ..... *andrei* Emery

   Antennal scape in repose failing to reach the occipital margin by an amount no greater than its greatest thickness; epinotal spines well-developed; thoracic dorsum coarsely, longitudinally rugose ..... *nevadensis rudis* Wheeler

Leptothorax andrei Emery

A few workers, assignable to this species, were taken in disturbed Pinyon-Juniper on Rainier Mesa. The nest was not found. This small species can be recognized by its yellow color, its feebly shining head, its very short, angulate epinotal armature, and the broad petiolar node which, viewed in profile, is nearly as wide apically as basally. The ants generally construct small nests beneath stones. For additional information on *andrei* and its allies, the reader is referred to a paper by Cole (1958).

Leptothorax nevadensis rudis Wheeler

Sparse and small colonies were found in the disturbed Pinyon-Juniper community on Rainier Mesa. The workers were sluggish and docile.

The worker of this subspecies is a small, brownish black ant. The thoracic dorsum is completely covered with coarse, longitudinal rugae except for a punctate area on the mesonotum. The epinotal spines are rather well developed, and the postpetiole is a little less than twice the width of the petiole.

Subfamily Dolichoderinae

A Key to the Genera of the Subfamily Dolichoderinae for Identification of the Workers

1. Epinotum with a prominent tooth-like protuberance directed upward from the junction of the basal and declivious faces; third segment of the maxillary palp very long, as long as or longer than the three succeeding segments combined ..... *Dorymyrmex*

Epinotum without such a protuberance, unarmed, the junction of the two faces rounded or angular, third segment of the maxillary palp not usually long, shorter than the three succeeding segments combined 2

2. Dorsum of the thorax without a conspicuous impression at the mesoepinotal suture; hairs on the thorax abundant, gastric pubescense dense, workers somewhat polymorphic *Liometopum*

Dorsum of the thorax with a conspicuous impression at the mesoepinotal suture; hairs on the thorax very sparse; gastric pubescence dilute *Iridomyrmex*

Genus *Dorymyrmex* Forel

A Key to Species of the Genus *Dorymyrmex* for Identification of the Workers

1. Clypeus broadly and evenly rounded, without a trace of a median angle or carina; head and thorax deep red or reddish yellow, gaster brownish black or black *bicolor* Wheeler

Clypeus distinctly angular or subcarinate medially; body not contrastingly bicolored *pyramicus* (Roger)

Dorymyrmex bicolor Wheeler

Rapidly moving, foraging workers of this species were encountered repeatedly in the Larrea-Franseria community to which the nests were restricted. This common, typically desert species constructed, in unshaded areas, nests marked by exquisite, semicircular or circular craters of fine loose sand. The worker can be distinguished from that of its nearest relative, *pyramicus*, by its bicolored body, a feature that appears to be genetically fixed.

Dorymyrmex pyramicus (Roger)

Very closely allied to *bicolor*, *pyramicus* was also found nesting, and in its greatest numbers, in the Larrea-Franseria community, where it was often sympatric with *bicolor* at the same stations. It occurred also, but to a much more limited extent, in the Coleogyne and mixed communities.

Genus *Liometopum* Mayr

Liometopum occidentale luctuosum Wheeler

A single small colony of this species was found in disturbed Pinyon-Juniper on Rainier Mesa. The nest was in soil beneath light detritus at the base of a juniper.

The worker caste shows a considerable variation in size (2.5 to 5 mm in length), has very sparse pilosity, and is rather uniformly deep brown in color and rather strongly shining. As is true of other members of its genus, *luctuosum* possesses the characteristic and unpleasant "*Liometopum* odor."

Genus *Iridomyrmex* Mayr

Iridomyrmex pruinosum analis (F. André)

Present in all plant communities studied at the test site, this common ant constructs its nests beneath stones, at the base of plants, and in fully exposed areas where it makes a small, irregular or circular mound of soil. The small workers run about very rapidly and apparently erratically. They can withstand very high soil surface temperatures, and were observed foraging on trails during hot summer days.

The pale yellow and yellow and brown workers are characterized by their long, sparse, erect body hairs and the dilute pubescence on the head and thorax which does not obscure the shining surface. The worker is virtually identical to that of *bicolor*, except for its concolorous brown body. Nest location and construction of the two species are the same.

Subfamily Formicinae

A Key to the Genera of the Subfamily Formicinae for the Identification of the Workers

1. Thoracic dorsum, in lateral view, evenly convex, the epinotum not depressed below the level of the promesonotum, the mesoepinotal suture slightly or not at all impressed; antennal scapes inserted well behind the posterior edge of the clypeus . . . . . *Camponotus*

   Thoracic dorsum, in lateral view, with the epinotum distinctly depressed below the level of the promesonotum, the mesoepinotal suture well impressed; antennal scapes inserted at or near the posterior border of the clypeus 2

2. Maxillary palps very short, 3-segmented . . . . . *Acanthomyops*

   Maxillary palps notably longer, 6-segmented 3

3. Maxillary palps longer than the head, the third and fourth segments very long and as long as or longer than the two terminal segments combined; psammophore present . . . . . *Myrmecocystus*

   Maxillary palps shorter or no longer than the head, the third and fourth segments shorter than the two terminal segments combined; psammophore absent 4

4. Frontal carinae prominent, their lateral margins slightly reflected upward; ocelli very distinct . . . . . *Formica*

   Frontal carinae less well marked, their lateral margins flattened; ocelli indistinct or absent . . . . . *Lasius*

Genus *Camponotus* Mayr

A Key to Species of the Genus *Camponotus* for Identification of the Workers

1. Middle of anterior clypeal border depressed, bearing a narrow, median notch; length of major less than 8 mm . . . . . *hyatti* Emery

   Middle of anterior clypeal border not bearing a narrow, median notch; length of major notably greater than 8 mm 2

2. Antennal scape of the major distinctly flattened at the base, the flattened portion forming a small lateral lobule . . . . . *maccooki* Forel

   Antennal scape of the major not flattened at the base or, if flattened, without a lateral lobule 3

3. Cheeks strongly shining, with minute inconspicuous punctures; antennal scape not flattened at the base; head black; thorax and gaster yellow, often suffused with brown; tibiae and tarsi strongly infuscated . . . . . *ocreatus* Emery

   Cheeks feebly shining, the punctures coarser and conspicuous; antennal scape flattened at the base; body medium to very deep red . . . . . *vicinus* Mayr

Camponotus hyatti Emery

A single small colony of *hyatti* was found nesting in the soil beneath a dead juniper limb in a mixed community. The species is a member of the subgenus *Myrmentoma*, which is characterized by having a narrow, median notch in the depressed middle of the anterior clypeal border, and is the only member of that subgenus known from the test site. The highly polished, jet black gaster contrasts sharply with the shining, bright red head and thorax.

Camponotus maccooki Forel

This species was limited largely to the Grayia-Lycium community, but it occurred spottedly in Pinyon-Juniper also. Nests were beneath

stones. The major workers are rather large ants of a rather uniform yellowish brown or reddish brown color. They are readily identifiable by their antennal scapes which are distinctly flattened basally and bear a lateral lobule.

Camponotus vicinus Mayr

Nests of *vicinus* were found frequently in the Pinyon-Juniper community, of which they are a characteristic element, but were seen nowhere else at the test site. The workers are very large ants with a deeply ferrugineous red thorax and a black head and gaster. Colonies were beneath the larger rocks in partly shaded areas.

Camponotus ocreatus Emery

Except for two workers found in the Larrea-Franseria community, all members of this species occurred in the mixed community. A single nest was located beneath a small stone. The black head and appendages contrasting with the yellow thorax and gaster give the worker a striking appearance.

Genus *Lasius* Fabricius

A Key to Species of the Genus *Lasius* for Identification of the Workers

1. Very small ants (width of pronotum usually less than 0.54 mm.); eyes minute, typically with 11 ommatidia in a line along the long axis of the eye; color yellowish brown ..... *siticus* Wilson

   Larger ants (width of pronotum usually more than 0.54 mm.); eyes larger, typically with 14 or 15 ommatidia in a line along the long axis of the eye; color consistently darker, usually dark brown ..... *crypticus* Wilson

Lasius siticus Wilson

Colonies of this species were found only in disturbed Pinyon-Juniper, where they were considerably more common than those of *crypticus*. The nests were beneath stones at the same stations as those occupied by *crypticus*. The sexual castes were in nests between June 23 and July 10.

The workers are of a pale brown color and are notably smaller than those of *crypticus*. The eyes are small, having only 10 to 12 ommatidia across the maximum diameter of the eye rather than the usual 14 or 15 of *crypticus*.

This is a new Nevada record for this species.

Lasius crypticus Wilson

A few nests of *crypticus* were found in disturbed Pinyon-Juniper on Rainier Mesa. All were in the soil beneath stones in open areas.

The dark brown workers have a sparse pilosity, and erect hairs are absent from the antennal scapes and tibiae.

Genus *Acanthomyops* Mayr

Acanthomyops latipes (Walsh)

Colonies of *latipes* were found only in disturbed Pinyon-Juniper on Rainier Mesa. The nests were located rather deeply in the soil beneath stones in partially shaded areas. Queens of both alpha and beta types were taken. The latter is an especially interesting ant. The body is extremely hairy, the femora and tibiae are greatly compressed and enlarged, so that they contrast strongly with the slender tarsi, and the antennal scapes are gradually much incrassated from base to apex.

The worker's body, including the gula, is densely hairy and of a rather concolorous brownish yellow. The antennal scape, in repose, does not surpass the occipital border. Viewed in profile, the scale of the petiole has a blunt apex; seen from behind, the scale is somewhat flattened and entire. The worker possesses the "citronella odor" that is characteristic of all members of its genus.

Genus *Myrmecocystus* Wesmael

A Key to Species of the Genus *Myrmecocystus* for Identification of the Workers

1. Eyes large, their greatest diameter notably longer than the length of the first funicular segment; ocelli small and obscure or absent; mandibles with eight teeth . . . 2

   Eyes small, their greatest diameter about equal to the length of the first funicular segment; ocelli large and prominent; mandibles with seven teeth . . . 3

2. Petiolar scale thick from front to back; erect hairs on crest and sides of petiolar scale numerous and conspicuous; length range 4.0 to 9.5 mm . . . *mexicanus* Wesmael

   Petiolar scale thin from front to back; erect hairs on crest and sides of petiolar scale very sparse or absent; length range 2.5 to 5.5 mm . . . *mojave* Wheeler

3. Erect hairs delicate, sparse or absent on the cheeks; pubescense short and sparse, not notably obscuring the ground surface; body rather shining . . . 4

   Erect hairs coarse and numerous, abundant on cheeks; pubescence longer and dense, mostly obscuring the ground surface; body often silvery but not shining . . . *comatus* Wheeler

4. Erect hairs sparse or absent on the femora and tibiae, confined chiefly to the flexor surfaces; small ants, length 2.0 to 3.5 mm; body a concolorous dark brown . . . *lugubris* Wheeler

   Erect hairs abundant on all surfaces of the femora and tibiae; larger ants, length 3.0 to 6.5 mm; body bicolored, the head and thorax notably lighter than the gaster, and generally red or reddish brown . . . *mimicus* Wheeler

Myrmecocystus comatus Wheeler

M. comatus was well represented in the Grayia-Lycium, Larrea-Franseria, Atriplex-Kochia, and mixed communities; scarce in the Coleogyne and Salsola communities; and rare in Pinyon-Juniper areas. It nests in open areas between shrubs. Each nest is marked either by only a hole in the soil or by a crude soil crater. Most colonies were very populous.

By far the hairiest member of its genus and accordingly well named, *comatus* is best, but not easily, distinguished from its close relatives, by that trait. The dull red head, the darker infuscated thorax, and the silvery, densely pubescert, black gaster are unique features. The workers vary in length from 3.5 to 6.5 mm.

Myrmecocystus lugubris Wheeler

This species was found only in the Atriplex-Kochia community where it was a minor component of the ant fauna. The small colonies occupied exposed areas, and their nests were marked by an entrance around which soil was loosely and irregularly dispersed. The workers were active during the intense heat of the summer day. They appeared to be most numerous on the shrubs over which they moved swiftly.

The very dark brown or black, polymorphic workers are of rather small stature, with a body length of 2.5 to 3.5 mm. Erect hairs on the body, and especially on the appendages, are rather sparse. The entire body is somewhat shining.

Myrmecocystus mexicanus Wesmael

Nests of this common desert species were found most abundantly in the Grayia-Lycium community, but they were rather numerous in the mixed, Salsola, and Coleogyne communities, and were scarce in the Larrea-Franseria community. All colonies were in unshaded soil between plants, and were marked with a broad, circular entrance of coarse, tightly packed sand (Fig. 19). The ants are nocturnal foragers.

This species has strongly polymorphic workers (4.5 to 9.5 mm in length) which can move with great rapidity and agility. Although most specimens were referable to the typical *mexicanus*, some (even in the same nests) were characteristic of the subspecies *hortideorum* McCook, which supposedly differs from *mexicanus* by its nearly concolorous yellow body. I predict that future revisionary studies of *Myrmecocystus* will show that the two forms are synonymous.

Fig. 19. Mound of *Myrmecocystus mexicanus* in a mixed community.

Myrmecocystus mimicus Wheeler

A common occupant of the Larrea-Franseria community, *mimicus* was well represented in the Grayia-Lycium, but only moderately so in the Atriplex-Kochia, Salsola, and mixed communities, and poorly so in Coleogyne. The nests and nesting sites were like those of *comatus*.

The workers possess erect hairs that are notably more delicate and less abundant than those of *comatus*. The two species are not separable by color differences, but the body of *mimicus* is more shining, and the pubescence on the gaster is not sufficiently dense to obscure the shining surface or produce a silvery luster.

Myrmecocystus mojave Wheeler

At the test site *mojave* is restricted to Pinyon-Juniper areas. Strong colonies were found nesting beneath stones or in soil without cover and marked by a circular crater of small pebbles with a large, irregular, central entrance. The workers are nocturnal and crepuscular foragers. The sexual castes, as well as semirepletes, were in nests on Rainier Mesa from middle to late June.

The workers of *mojave*, like those of *mexicanus*, are polymorphic, but less strongly so. They vary in length from 3 to 5 mm. The scale of the petiole is notably thinner, viewed laterally, than is that of *mexicanus*.

Genus *Formica* Linné

A Key to Species of the Genus *Formica* for Identification of the Workers

1. The combined second and third funicular segments of the antenna not more than 1 1/5 times as long as the first segment and often not that long 2

   The combined second and third funicular segments at least 1¼ times as long as the first segment and usually longer 4

2. Extensor surface of antennal scape with a number of short, delicate, erect, silvery hairs ..... *lasioides* Emery

   Extensor surface of antennal scape without erect hairs, except for a few at the extreme tip 3

3. Thorax with numerous erect hairs; body surface moderately shining ..... *neogagates* Emery

   Thorax without erect hairs or with only one or two erect hairs; body surface strongly shining ..... *limata* Wheeler

4. Erect hairs on the pronotum distinctly clavate or spatulate ..... *microgyna* Wheeler

   Erect hairs on the pronotum simple, not clavate or spatulate 5

5. Antennal scape considerably longer than distance from middle of clypeal border to midoccipital border; base of epinotum notably convex, the angle between it and the declivious surface poorly defined; posterior surface of petiole convex ..... *moki* Wheeler

   Antennal scape not longer than distance from middle of clypeal border to midoccipital border, or if longer, the epinotum distinctly angular; posterior surface of petiole not convex 6

6. Anterior border of clypeus distinctly excised; gaster evenly covered with stout, rather long, blunt, erect, silvery hairs ..... *obtusopilosa* Emery

Anterior border of clypeus not excised; gaster without such pilosity 7

7. Head and thorax of the larger workers ferrugineous red and generally notably lighter than the gaster or, if infuscated, the infuscation not obscuring the ferrugineous ground color; frontal area shining; frontal lobes strongly divergent behind 8

Body concolorous or, if bicolored, the thorax lighter than the head and gaster; frontal area opaque, frontal lobes not strongly divergent behind, often parallel 9

8. Head of the major worker, excluding the mandibles, as broad as long or broader than long; erect hairs on the thorax unequal in length; cephalic hairs nearly as numerous as, and only a little longer than, those on the thorax ..... *obscuripes* Forel[7]

Head of the major worker, excluding the mandibles, longer than broad; erect hairs on the thorax short, subequal in length; cephalic hairs considerably longer and less dense than those on the thorax ..... *integroides planipilis* Creighton

9. Gula with erect hairs; worker caste strongly polymorphic; head of largest workers (mandibles excluded) quadrate, as broad as or broader than long ..... *subpolita camponoticeps* Wheeler

Gula without erect hairs; worker caste not polymorphic; head longer than broad 10

10. Body black; when in full-face view, eyes of largest workers reaching or projecting beyond the head margin ..... *fusca* L.

Thorax more or less red; when in full-face view, eyes of largest workers not reaching the head margin ..... *neorufibarbis* Emery

Formica fusca Linné

This species appeared to be restricted to Pinyon-Juniper areas, where the nests were beneath individual or clusters of stones. Colonies were sparse and also unusually weak for this species. The ants are active scavengers.

The workers are entirely black and of medium size (4 to 7 mm in length), and they have a moderately shining and very sparsely hairy body. The gaster is moderately pubescent and often has a silky luster.

Formica integroides planipilis Creighton

This ant was limited to Pinyon-Juniper areas and was more representative of the undisturbed than the disturbed ones. Each nest was surmounted by a dome-shaped, thatched mound fashioned of assorted, rather tightly packed detritus, and constructed against or around a shrub that was ultimately killed by the ants (Fig. 20). Brood was found in chambers within the mound as well as in those underground. The colonies were very populous. When the mounds were disturbed, workers in large numbers attacked the intruder and ejected their "formic acid" spray.

The workers vary considerably in size, and may be designated as minors, media, and majors. The majors are distinctly bicolored, with dull red head and thorax and brownish black gaster; the red portions of the media are more or less marked with brown; and the minors are strongly and extensively infuscated. The legs are brownish black in all workers. The body is very hairy, the erect hairs of the thorax being short and subequal in length, whereas those of the head are longer and sparser. Erect hairs on the middle and hind tibiae are numerous and generally cover all surfaces. The gaster is opaque and densely pubescent.

Formica lasioides Emery

This species was sparsely represented in the ant fauna of disturbed Pinyon-Juniper on Rainier Mesa. The nests were beneath small stones in open areas. The workers were very timid.

The worker of this comparatively small ant (3.5 to 4.5 mm in length) has a smooth and shining body which is generally of a medium brown color. There are a number of erect, short, delicate hairs along the extensor surface of the antennal scape.

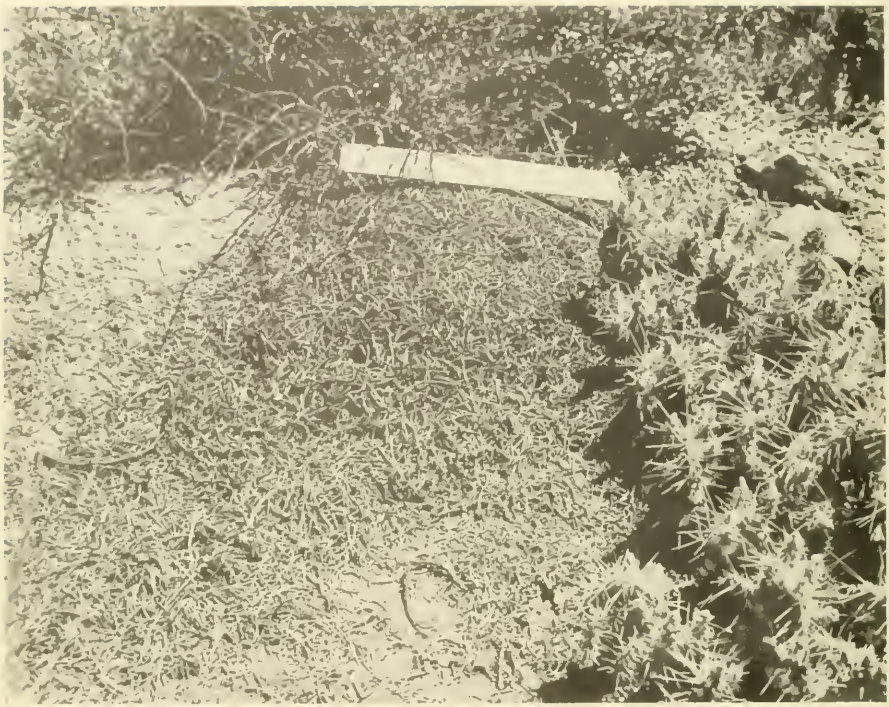

Fig. 20. Thatched mound of *Formica integroides planipilis* in a Pinyon-Juniper community. Ruler is one foot in length.

Formica limata Wheeler

Two small colonies of this ant were found under small stones in disturbed Pinyon-Juniper on Rainier Mesa. The species appeared nowhere else at the test site.

The worker resembles that of *lasioides* and *neogagates*. The characters in the key will segregate it readily. Its most striking characteristic is the very strongly shining body.

Formica microgyna Wheeler

A single worker assignable to this species was taken from a can trap in Pinyon-Juniper. No nest was found.

The worker of *microgyna* has a rather light ferruginous head and thorax, and a black, strongly opaque gaster. It is characterized chiefly by the presence of a few clavate hairs on the pronotum and by the pilosity of the femora and tibiae which includes erect hairs in addition to those on the flexor surfaces.

Nests of *microgyna* are generally constructed in open areas under stones which are ultimately banked peripherally with detritus.

Formica moki Wheeler

A single colony of this species was found in a Pinyon-Juniper area near Tippipah Spring. The nest was in open, stony soil beneath a small rock. Numerous workers and a few males were collected, but no females were encountered. The workers are 4.0 to 5.8 mm in length and of a dull ferruginous red color, with the posterodorsal part of the head, and the petiole, gaster, and legs dark brown. The hairs are sparse and erect. The body surface is subopaque and finely and densely granulose. In certain lights the posterodorsal portion of the head and the gaster have a rather bronzy luster.

The male caste is described herewith for the first time.

Male. HL 1.41 to 1.41 mm, HW 1.60 to 1.74 mm, CI 113 to 123, SL 1.67 to 1.71 mm, SI 98 to 104, EL 0.87 to 0.91 mm, EW 0.49 to 0.53 mm, OI 62 to 65, TL 3.50 to 3.80 mm, PNL 0.49 to 0.53 mm, PNW 0.95 to 1.03 mm.

Antennal scape long, its length approximately equal to the combined lengths of funicular segments 2 to 5, inclusive. Median lobe of clypeus strongly and evenly convex, its anterior border entire.

Petiolar node, in profile, notably broader basally than apically, the apex acute but rather thick. Petiolar node, viewed from above and behind, with its apex prominently, broadly, and evenly concave; the corners rather sharply rounded.

Paramere of genitalia as shown in Fig. 21, volsella as in Fig. 22, and aedeagus as in Fig. 23. Sternite IX of abdomen as illustrated in Fig. 24.

Head, thorax, and petiole densely and finely granulose; subopaque. Gaster densely and more finely granulose; the surface somewhat shining.

Cephalic pilosity mostly very sparse, the hairs limited chiefly to the mandibles (where they are long and dense) and the anterior margin of the clypeus; absent from occipital corners of the head. Thorax (except the epinotum) mostly densely pubescent, with a few scattered, short, slender, pointed, golden hairs on scutum and scutellum; epinotum, petiole, and dorsum of base of first segment of gaster covered with a dense pile of very short, erect and suberect, slender hairs forming a rather even, plush-like investiture; each corner of apex of petiolar node with two or three comparatively long, erect hairs. Gaster chiefly without hairs, except for those described on the first segment and for a very few, short, suberect, delicate ones along the posterior border of the segments; pubescence on gaster appressed, widely spaced, not obscuring the surface.

Head deep brown; thorax, and especially the dorsum of the scutum, a little lighter; petiole, legs, and gaster dusky yellow; antennae light brown.

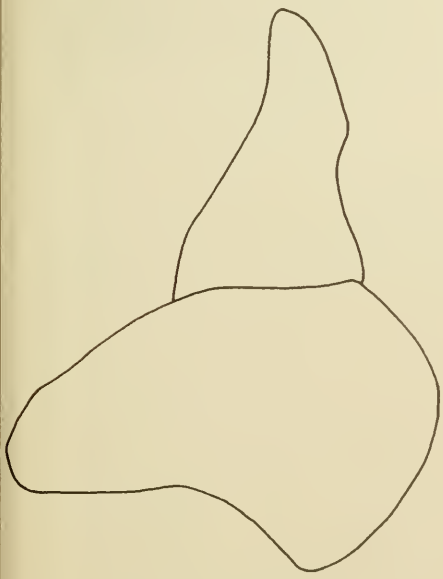

Fig. 21. Paramere of a male *Formica moki.*

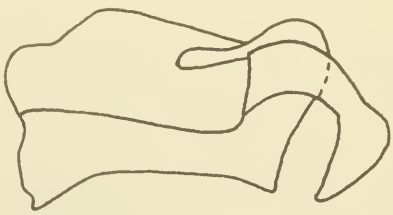

Fig. 22. Volsella of a male *Formica moki.*

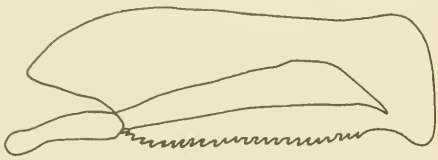

Fig. 23. Aedaegus of a male *Formica moki.*

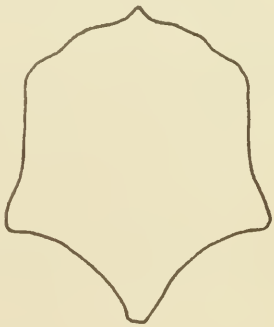

Fig. 24. Abdominal sternite IX of a male *Formica moki.*

Described from six males collected by the writer on July 25, 1962. *F. moki*, heretofore unported from Nevada, is known also from southern Utah and northern Arizona, where it appears to be a very uncommon species.

Formica neogagates Emery

Colonies of *neogagates* were found at the test site only in Pinyon-Juniper areas, but they were considerably better represented than were those of *lasioides* and *limata*. Nests and nesting sites were similar to those of the latter two species.

The worker of *neogagates* resembles closely that of both *lasioides* and *limata* in color and average size. Unlike that of *lasioides*, however, its antennal scapes have no erect hairs. Its body is only moderately shining.

Formica neorufibarbis Emery

A few colonies of this ant were found under stones in partial shade in the Pinyon-Juniper community.

The worker of this medium-sized ant (length 3 to 6 mm) has a brown to black head and gaster, and a light to deep red thorax which is often strongly infuscated, especially on the pronotum. The head and thorax are subopaque; the gaster is rather smooth and shining.

Formica obtusopilosa Emery

A few colonies of this ant were found in a mixed plant community with scattered sparse juniper and *Artemisia*. The nests were in rather coarse, gravelly soil of unshaded areas. They were marked by a rather large, irregular entrance surrounded by a narrow, uneven circlet of small pebbles. Workers were numerous in the colonies. My attempts to find males, which have never been described, were unsuccessful

The large (up to 7 mm in length), handsome workers of *obtusopilosa* have the head and thorax colored a rich, uniform, ferrugineous red, and the gaster an opaque black. The conspicuous, long, robust, blunt, silvery hairs which evenly cover the gaster are definitive of this taxon. As in other closely related taxa, the anterior clypeal margin is distinctly, medially emarginate.

Formica subpolita camponoticeps Wheeler

Restricted to the Pinyon-Juniper community, colonies of this taxon were rather common under stones in sunny areas. The workers are strongly polymorphic and vary in length from 2.5 to 6.0 mm.

The workers have a shining body with castaneous brown head, brownish or reddish yellow thorax, and piceous brown gaster. The head of the larger workers is at least as broad as long, excluding the mandibles, and its gula bears erect hairs. There are a few erect hairs also on the front and occiput as well as on the dorsum of the pronotum.

Subfamily Dorylinae

Genus *Neivamyrmex* Borgmeier

Neivamyrmex minor (Cresson)

A few males of this species were attracted to black light on July 21 in Pinyon-Juniper on Rainier Mesa. The worker caste is unknown.

LITERATURE CITED

Allred, D. M., D E. Beck, and C. D. Jorgensen. 1963. Biotic communities of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., 2(2):1-52.

Andrews, H. 1916. A new ant of the genus *Messor* from Colorado. Psyche, 23:81-3.

Barnum, A. H. 1964. Orthoptera of the Nevada Test Site. Brigham Young Univ. Sci. Bull., Biol. Ser., 4(3):1-134.

Cole, A. C. 1955. Studies of Nevada ants. I. Notes on *Veromessor laricersi* M. R. Smith and a description of the queen (Hymenoptera: Formicidae). J. Tennessee Acad. Sci., 30:51-2.

Cole, A. C. 1958. North American *Leptothorax* of the *nitens-carinatus* complex (Hymenoptera: Formicidae). Ann. Entomol. Soc. Amer., 51:535-8.

Cole, A. C. 1963. A new species of *Veromessor* from the Nevada Test Site and notes on related species (Hymenoptera: Formicidae). Ann. Entomol. Soc. Amer., 56:678-682.

Cole, A. C. 1965a. Discovery of the worker caste of *Pheidole* (*P.*) *inquilina*, new combination (Hymenoptera: Formicidae). Ann. Entomol. Soc. Amer., 58:173-5.

Cole, A. C. 1965b. A monographic revision of the genus *Pogonomyrmex* Mayr in North America (Hymenoptera: Formicidae). (Unpub. ms.).

Gregg, R. E. 1955. The rediscovery of *Veromessor lobognathus* (Andrews) (Hymenoptera: Formicidae). Psyche, 62:45-52.

Gregg, R. E. 1958. Key to the species of *Pheidole* (Hymenoptera: Formicidae) in the United States. J. New York Entomol. Soc., 66:7-48.

Smith, M. R. 1941. Two new species of *Aphaenogaster* (Hymenoptera: Formicidae). Great Basin Nat., 2:118-21.

Smith, M. R. 1951. Two new ants from western Nevada (Hymenoptera: Formicidae). Great Basin Nat., 11:91-6.

Smith, M. R. 1957. Revision of the genus *Stenamma* Westwood in America north of Mexico (Hymenoptera: Formicidae). Amer. Midland Nat., 57:133-74.

Smith, M. R. 1963. A new species of *Aphaenogaster* (*Attomyrma*) from the western United States (Hymenoptera: Formicidae). J. New York Entomol. Soc., 71:244-6.

Wheeler, G. C. and J. Wheeler. 1956. *Veromessor lobognathus* in North Dakota (Hymenoptera: Formicidae). Psyche, 63:140-5.

Wheeler, G. C. and J. Wheeler. 1959. *Veromessor lobognathus*: second note (Hymenoptera: Formicidae). Ann. Entomol. Soc. Amer., 52:176-9.

Wheeler, G. C. and J. Wheeler. 1965. *Veromessor lobognathus*: third note (Hymenoptera: Formicidae). J. Kansas Entomol. Soc., 38:55-61.

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THE SPHAERODACTYLUS DECORATUS COMPLEX IN THE WEST INDIES

by
RICHARD THOMAS
and
ALBERT SCHWARTZ

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AUGUST, 1966

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THE *SPHAERODACTYLUS DECORATUS* COMPLEX IN THE WEST INDIES

by

Richard Thomas and Albert Schwartz[1]

INTRODUCTION

On the Greater Antillean islands of Cuba and Hispaniola, and the Bahama Islands occur geckos of the genus *Sphaerodactylus* in which the juveniles are typically boldly marked with from two to five dark crossbands. Adults are sexually dichromatic—the females retain a modified and usually less intense juvenile pattern, and the males are either unicolor and patternless, or have large dark dots on a paler ground on the dorsum and head. The group was recently reviewed in part by Schwartz (1958). Inasmuch as additional material has been collected since that time and several new names applied to members of the group, it seemed appropriate to revise the complex completely. A large amount of the new material was collected in Cuba through the efforts of Major Chapman Grant, whose interest in these geckos resulted in his description of three new species of this (the *decoratus*) complex. Although there are still grossly inadequate numbers of these lizards from many areas of eastern Cuba, the material available indicates that a complete reassessment of the named forms and their interrelationships is in order. As will be seen, this strikingly marked group of geckos is considerably more complex than originally thought.

We collected *decoratus* group members in the Bahamas and Cuba. These specimens are in the Albert Schwartz Field Series (ASFS) and the collection of the senior author (RT). Other Cuban material collected by the junior author and John R. Feick, William H. Gehrmann, Jr., Ronald F. Klinikowski, David C. Leber, James D. Smallwood, and Barton L. Smith between the years 1957 and 1960 under the sponsorship of National Science Foundation grants G-3865 and G-6252, has been deposited in the American Museum of Natural History (AMNH). Messrs. Klinikowski and Leber were also students in the National Science Foundation Undergraduate Participation program during 1959 and 1960. We are indebted to Dennis R. Paulson and C. Rhea Warren for visiting Cat and Long islands in the Bahamas on our behalf, and to Miss Patricia A. Heinlein for assistance in collecting these geckos on South Bimini. The senior author visited the United States Naval Base at Guantánamo Bay, Cuba, through the cooperation of the U.S. Coast Guard and the officers and men of the U.S. Coast Guard cutter *Hollyhock*. We extend our sincere thanks to all of these people for their assistance and companionship in the field; without their efforts far less material would be available for our use.

In addition to our own material we borrowed material from the following collections whose respective curators and their assistants were most cooperative in lending us pertinent specimens: American Museum of Natural History (AMNH), Charles M. Bogert and George W. Foley; Academy of Natural Sciences of Philadelphia (ANSP), James N. Böhlke and Edmond V. Malnate; Brigham Young University (BYU), Wilmer W. Tanner; Carnegie Museum (CM), Neil D. Richmond and Clarence J. McCoy; Chicago Natural History Museum (CNHM); Robert W. Inger and Hymen Marx; Museum of Comparative Zoology (MCZ), Ernest E. Williams; University of Illinois Museum of Natural History (UIMNH), Hobart M. Smith; Museum of Zoology, University of Michigan (UMMZ), Charles F. Walker and Dale L. Hoyt; United States National Museum (USNM), Doris M. Cochran and James A. Peters; Yale Peabody Museum (YPM), Charles A. Reed. Attention is also directed to the collections made by George B. Rabb while on the Van Voast-American Museum of Natural History Bahama Islands Expedition between December, 1952 and May, 1953. These lizards, presently divided between the American Museum and the University of Michigan, are of special interest and add significantly to the quantity and quality of the available Bahaman material.

Most of the illustrations are the work of Wayne King. His attention to detail aided greatly in visualization of the various forms involved, and we thank him for his excellent delineations.

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HISTORICAL SUMMARY

The names applied to members of the *decoratus* group and their type localities are the following:

(1) *decoratus* Garman, 1888 - Rum Cay, Bahama Islands

(2) *flavicaudus* Barbour, 1904 - Mangrove Cay, Andros Island, Bahama Islands

(3) *torrei* Barbour, 1914 - Santiago de Cuba, Oriente Province, Cuba

(4) *gibbus* Barbour, 1921 - Stocky Island, Exuma Cays, Bahama Islands

(5) *stejnegeri* Cochran, 1931 - St. Michel de l'Atalaye, Dépt. de l'Artibonite, Haiti

(6) *drapetiscus* Schwartz, 1958 - 2 miles east of Playa de Guanabo, Cueva de Rincón de Guanabo, Habana Province, Cuba

(7) *spielmani* Grant, 1958 - Guantánamo, Oriente Province, Cuba

(8) *alayoi* Grant, 1959 - United States Naval Base, Guantánamo, Oriente Province, Cuba

(9) *ruibali* Grant, 1959 - United States Naval Base, Guantánamo, Oriente Province, Cuba

We examined the holotypes and syntypes of all the above forms. A total of 762 specimens of this complex was at our disposal.

All of the names listed above were proposed as full species with the exception of *drapetiscus*. Barbour (1921:227-228) considered *flavicaudus* a synonym of *decoratus;* the former name was based upon a series of fourteen syntypes, all males and without pattern. Barbour indicated that in *decoratus*, males were patternless and females were transversely crossbarred, a condition which had heretofore gone unnoted. In the same publication, Barbour (*op. cit.*:228-229) described *S. gibbus*, based on two specimens from Stocky Island and one from a cay off Roseville, Great Exuma. This species was diagnosed as being "coarsely spotted with large dots"; the holotype is a male. One of the paratypes (MCZ 13437) is barely spotted dorsally.

The name *torrei* was based upon two females and one juvenile (holotype and two paratypes); all are prominently crossbanded. Later, Barbour (1921:230-231) noted that male *torrei* are "uniform gray-brown or very faintly barred." However, Barbour commented under the discussion of *gibbus* that two Cuban specimens (one from Santiago de Cuba, the other from Guantánamo) were spotted like *gibbus*, but in habit and squamation were like *torrei*. Even at this early date in the history of the *decoratus* group, confusion was existent.

Hecht (1954:133) first suggested that *decoratus* and *gibbus* were conspecific. This course of action was followed by Schwartz (1958), who also considered *torrei* conspecific with *decoratus* and described *drapetiscus* as a subspecies of *decoratus*. Grant (1956:247-248) had previously discussed the status of *gibbus* (which had been reported from Cuba on the basis of spotted males), and stated that Cuban specimens of "*gibbus*" were in actuality spotted male *torrei*. Thus, the distribution of *torrei* was extended to those Bahaman islands where spotted males (=*gibbus*) occur.

To complicate the situation further, Grant (1958, 1959a and b) named three species (*spielmani, alayoi, ruibali*) from Guantánamo and the United States Naval Base at the Bahía de Guantánamo. Since *torrei* had already been recorded from this area (at Boquerón by Cochran, 1934: 12), the interrelationships of these four species was at once questioned. Such an abundance of similar species in one restricted area was not only unusual, but somewhat suspicious. Since Grant had not examined previously reported Oriente material, it was imperative that all these specimens be restudied to ascertain their status.

From this brief historical summary, it is obvious that the status of at least the Cuban members of the complex—and in part their Bahaman relatives—has been confused. This is due to three major factors: (1) the relative paucity of specimens from many regions (a condition which still persists); (2) lack of centralized source for materials (no one has ever assembled all available material together at once); and (3) the inherent complexity of dealing with a number of sympatric (or even syntopic) forms, all of which are sexually dichromatic and some of which apparently have trenchant pattern changes in males. It speaks highly for the perspicacity of Major Grant that he was able to discern differences between lizards where others had failed. Had he examined in detail specimens other than his own, the *decoratus* complex would likely be better understood.

PROCEDURES AND TERMINOLOGY

We used the method of counting body scales first proposed by Grant (1937:507) but first used consistently and further elaborated upon by King (1962). Dorsal scales are counted dorsolaterally on a line from axilla to groin; ventrals are counted in the midline from the level of the axilla to that of the groin; and a count is taken around the midbody. Internasal scales are the small scales between the enlarged nasals which border the rostral posteriorly. Otherwise the counts taken are standard or self-explanatory.

The group of geckos dealt with here generally has been considered to have granular scales in contrast to some other forms which have flattened and imbricate scales. Although the two extremes are quite different, there is no true dichotomy, and transitions from one to the other can be found. Thus none of the forms considered can be said to have simply granular dorsal body scales (such as are found on the head) which are juxtaposed and not imbricate. All forms show a tendency toward imbrication, even where no actual overlap of adjacent scales occurs.

We used the following terms (in part after King, 1962) to categorize the types of dorsal scales. Scales may be *imbricate* or *granular* (simple granular scales are not typical of any of the forms in this assemblage, but those scales which show a distinct separation from adjacent ones are so called). Granular scales, as here used, have the posterior edge somewhat raised (true nondirectional granules, when present, are usually the result of injury). They may be *swollen* or *flattened*, or they may be *erected* or *flat-lying*. Erected scales must in some degree be swollen; but if scales are strongly erected, somewhat swollen but still flattened, imbricate, and close packed (*serried*), the term *papillate* is used. Extremely erected granular scales are termed *conical*. In outline (*i.e.*, viewed normal to the plane of the scale), scales are categorized as *rounded*, *acute*, or *obtuse*. Scales may be *smooth* or *keeled*, although keeling in the group is usually very weak and when present may not be evident on all of the dorsal scales.

Various categories of scales may be found on a single individual. For instance, the more granular scales are usually found in the middorsal zone, while on the sides they tend to be more imbricate and erected. Nevertheless, there are distinct trends in some forms on which certain categories of scales occur over a greater surface of the body and with greater frequency than on other forms.

The *decoratus* group of *Sphaerodactylus* is characterized by

(1) Large size

(2) Sexual dichromatism

(3) Ontogenetic pattern changes in both sexes (greater in males)

(4) Banded patterns (basically), *i.e.*, females and juveniles

(5) Basically granular dorsal scales (with nonabsolute trends in the various species toward flattening, imbrication, keeling, or swelling and erection)

(6) Large compact escutcheons with little or no extension onto thighs

(7) Few large hair-bearing scale organs around the apex of dorsal body scales

Sphaerodactylus ruibali differs in some of these requisites, but we include it as a peripheral member of the *decoratus* group because of its apparent relationship to *intermedius*. *Sphaerodactylus cinereus*, a large, granular-scaled form, is not included in the *decoratus* group because of strong differences in the pattern (although the basic juvenile pattern is banded), scalation, and ungual sheath. *Sphaerodactylus cinereus* may be a peripheral member of this group, but its relationships are not obviously with the forms here included, and it does not demand discussion for that reason.

The sequence in which we discussed the forms in this study is not intended to be phylogenetic. Rather, we started with *decoratus*, which, as the oldest named and most widespread geographically, makes an ideal starting point. Thereafter, the forms are associated roughly according to relationships as we see them—insofar as can be done in a linear sequence.

THE BAHAMAN SITUATION

The Bahama Islands are for the most part clustered in loose associations on shallow banks. Slight changes in sea level would cause profound changes in the land exposure of this archipelago. The Bahamas are presumed to have been completely or nearly completely submerged during the Pliocene and Pleistocene (Rabb and Hayden, 1957:8). The relatively slight changes in sea level necessary to produce alterations in the land area plus the probable effect of current erosion in enlarging channels (Clench, 1938:485) may well mean that proximal parts of adjacent islands have been only recently separated. These parts may show closer faunal affinities than parts of a presently continuous land mass which may have been united recently after having been separated for a long period. For instance, the geckos of the south tip of Eleuthera are more similar to those of Cat Island than to those of the rest of Eleuthera. Both of these islands are now separated by a substantial water gap but connected by a shallow strip (Clench, 1938) which may indicate that their association has been closer in the past. Also, it appears that islands may bear intermediate populations which have only recently become isolated, and so while not true intergrades, they still have the characteristics of the original intergradient populations.

Sphaerodactylus decoratus Garman

Sphaerodactylus decoratus Garman, 1888, Bull. Essex. Inst., 20:111. Type locality, Rum Cay, Bahama Islands; type specimen MCZ 6220.

Definition. Dorsal scales granular to swollen, rounded to acute and slightly imbricate; sometimes with conical or papillate scales, especially on posterior flanks; faint keeling present (in some specimens only in a small area, usually the lumbar region) in majority of specimens; large hair-bearing organs (three hairs) present on posterior face of scales; dorsals, axilla to groin, 46-69; ventral scales (including those of throat and chest) smooth, flattened, acute to rounded and imbricate (axilla to groin, 29-46); midbody scales 61-89; dorsal scales of tail smooth, flat-lying, imbricate and rounded to obtuse; scales beneath tail smooth, rounded, imbricate and enlarged midventrally. Internasals 0 to 4, mode 1 or 2; upper labials to mid-eye 3 to 5, mode 4; escutcheon large, compact, roughly triangular and with virtually no extensions onto thighs (5-10 X 6-23. Habitus stout; snout moderate in length and width; size moderate to large (to 40 mm snout-vent).

Female coloration: Dorsal ground color light (tan, gray, gray-brown); dark crossbands (3 to 5, axilla to groin; 5 to 7, snout to groin) some shade of darker brown with black edges; ocelli in bands white, with or without darker edges. Dark facial coloration extends to level just posterior to eyes; light areas on snout delimit loreal dark stripe and median snout stripe which forks posteriorly; narrow light band just behind facial markings followed by wide dark head band with ear situated about midway of its width. Dark neck band with two prominent paramedian light ocelli. Venters off-white to gray; dorsal markings extend onto venter in chin and throat region, usually becoming scrambled medially, forming a marbled pattern or fading out centrally. Juvenile coloration is like that of female but markings are more solid and contrasting.

Male coloration: (1) Unicolor dark to yellowish brown to bluish gray, tail and head more yellow, or (2) as just described but with pattern of scattered black or dark brown spots.

Range. Eastern Cuba from central Camagüey east, and the Bahamas north of the Crooked Island Passage (except San Salvador and unreported from many smaller islets) and excluding the Little Bahama Bank (Fig. 1).

Remarks. The dichromatism and particularly the variation in the males has caused considerable confusion. On the basis of spotted males from the Bahamas, Barbour (1921) named *S. gibbus* and later recorded it from Cuba. Grant (1956, 1959a) showed that *S. decoratus* was sexually dichromatic and interpreted the spotted pattern on males to be a transitory ontogenetic character. The juvenile pattern was thought to give way to the spotted which in turn was lost in older unicolor males. This sequence was presumed to have been demonstrated in a photograph (Grant, 1956: Fig. 1) of 12 males from the Banes area showing various degrees of spotting or its lack. We examined over 100 specimens from northern Oriente, most of them taken by Grant, and all males are spotted or are becoming so with the exception of a single series of 15 specimens that contains five unspotted males. We have reason to doubt the data for this series (see below). To us the evidence indicates that the degree of spotting is constant in the individual male after maturity, and its incidence in a population is constant and often geographically

circumscribed. In some populations males vary from completely spotted to completely unspotted, but in others either spotting or its lack is the predominant or exclusive condition. Bahaman populations exist in which the preponderance of spotted or unspotted males has remained constant in repeated collections over the past half-century.

In commenting on the specific distinctiveness of *drapetiscus* (=*intermedius*, *vide infra*) Grant (1959a) stated that the number of body bands is "fixed in each group" (presumably he meant species). On the basis of our broader survey of the group, we find this not to be so; band number, although constant in some species, is variable within single populations of some forms.

Sphaerodactylus decoratus decoratus
Garman

Sphaerodactylus gibbus Barbour, 1921, Mem. Mus. Comp. Zool., 47:228.

Definition. A race of *S. decoratus* characterized by moderate size; 3 or 4 bands (modally 4) between axilla and groin in females; bands relatively light, not heavy and dark, bordered posteriorly by light punctulations; ocelli lacking on body bands or present but small on the first band; throats faintly marked or not at all, and collar not prominently cleft middorsally; males spotted.

Range. The Exuma chain from Warderick Wells Cay south, Long Island, the Ragged Islands (known only from Great Ragged), and Rum Cay (Fig. 1). Records are not continuous

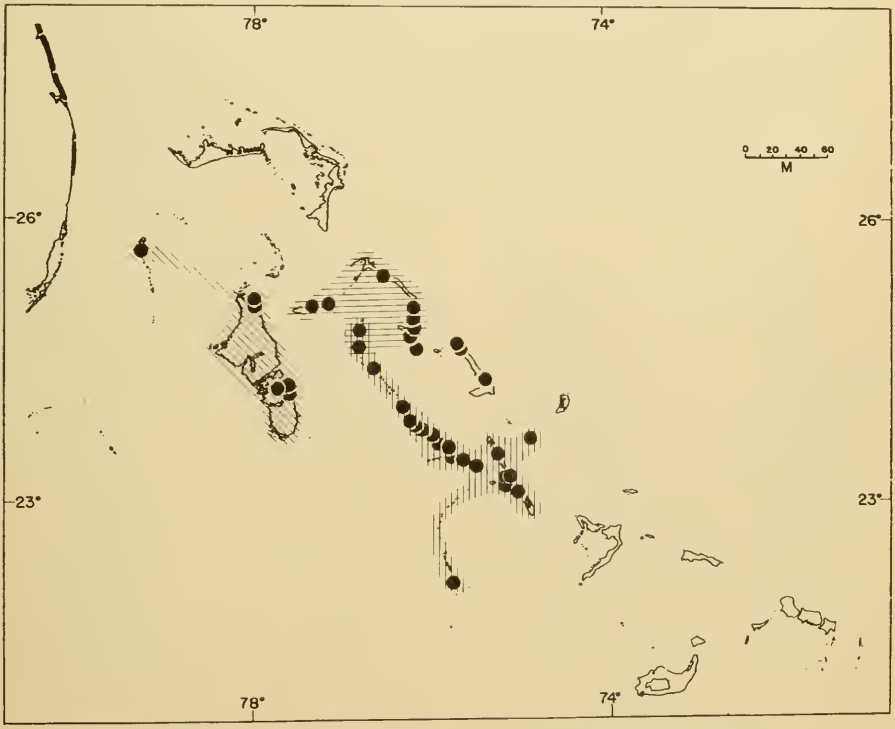


Fig. 1. Map of the Bahama Islands. Solid symbols indicate localities whence specimens of *Sphaerodactylus decoratus* have been examined. Ranges of subspecies are as follows: *S. d. decoratus*, vertical lines; *S. d. flavicaudus*, diagonal lines; *S. d. atessares*, horizontal lines. Overlap of symbols in the northern Exuma Cays indicates area of *atessares* influence on *S. d. decoratus*. Cat Island and the southernmost locality symbol on Eleuthera Island remain unshaded (see text for discussion).

(see specimens examined) and much of this range is presumptive. Also, the range is somewhat arbitrarily defined in the Exumas (see remarks below).

Variation. In 61 specimens, dorsal scales, axilla to groin, are 48-67, mean 59.0; ventrals, axilla to groin, 31-46, mean 37.1; midbody scales 67-86, mean 76.1. Internasals 1-4, mode 1 (Exumas) or 2 (Long); upper labials to mid-eye 3, 4 (mode) or 5. The largest male is 34 mm snout-vent, the largest female 37 mm snout-vent. Escutcheons compact with little extension onto thighs, range 6-8 X 7-13.

Female coloration (Fig. 2): Dark bands between axilla and groin 3 (11 specimens), 3/4 (4 specimens), 4 (37 specimens). Bands are typically light (brown to gray brown), minutely flecked with light, with a narrow black edge, and a border of buffy spots along the posterior edge; ocelli are white and minute when present (seldom); ground color light gray to tan. Collars typically darker than body bands; a few specimens show some middorsal splitting of collar; ocelli white and small, not always present. Tails banded with light gray to white and black. Throats faintly marbled in few specimens but usually lack markings. Males tan to brown or light gray, with a well-developed pattern of black spots (Fig. 3), a few specimens at the extremes of variation have only sparse spotting; one specimen from Big Farmers Cay lacks spots; ground color of head dull yellow, tail usually brighter. Iris color rich brown. (Colors given are from notes taken on Great Exuma specimens.)

Aberrant head pattern variants, in which the facial band is joined to the head band by two dorsolateral bridges of dark pigment or in which the light interband between these two elements has a pair of dorsolateral diverticula into the head band, occur in a high percentage of Long Island specimens. These variants are found more rarely elsewhere, and one occurs in the single specimen from Great Ragged.

Remarks. The exact limits of the range of this subspecies cannot be presently given. We have rather arbitrarily defined the northern limit in the Exuma chain. Specimens from the upper Exumas, particularly Leaf Cay, we believe to show the influence of the Eleuthera race in that they have only three body bands, modally two internasals, and the only male is unspotted. However, since the shift in internasal modality actually occurs much further down the chain, it is possible that the transition is more gradual or that various populations on the Exuma Cays have diverged independently to some extent. The Rag-

Figs. 2-5. Fig. 2. *Sphaerodactylus decoratus decoratus*, female, dorsal view; ASFS V7008, 0.8 mi NW George Town, Great Exuma Island, Bahamas. Fig. 3. *S. d. decoratus*, male, dorsal view; ASFS V7070, 9.8 mi NW George Town, Great Exuma Island, Bahamas. Fig. 4. *S. decoratus* subsp., female, dorsal view; MCZ 39554, Arthur's Town, Cat Island, Bahamas. Fig. 5. *S. d. atessares*, female, dorsal view; MCZ 81100, holotype, 4 mi N, 2.3 mi E Rock Sound, Eleuthera Island, Bahamas.

ged Islands are included on the basis of only one specimen from Great Ragged at the southern end of the chain; it agrees with S. *d. decoratus* as presently defined, but obviously nothing can be said about variation in the Raggeds. Long shows some divergence from the Exuma populations in internasal modality and coloration (splitting of the collar); it shows some influence of the rather divergent Cat Island population, which is not subspecifically allocated herein. We have called this cluster of populations *decoratus* because the single juvenile type from Rum Cay, which is geographically close, falls within the variation of these populations as far as can be determined. Should the Rum Cay population be found to be distinct, *gibbus* Barbour will be the next available name for those populations we are calling S. *d. decoratus*.

Specimens examined: Exuma Cays: Warderick Wells Cay, AMNH 76237; Great Guana Cay, CM 41046, 41058; Big Farmers Cay, AMNH 76232-36 (12 specimens), CM 41019-20; Cave Cay, CM 41022; Darby Island, UMMZ 117017-18 (8 specimens); **Great Exuma:** 9.8 mi NW George Town, ASFS V6978-81, V7070-75; approx. 2 mi SE Rolle Town, ASFS V6987-92; 0.8 mi NW George Town, ASFS V7001-09; 3.2 mi NW George Town, ASFS V7012-14, RT 1387; approx. 4 mi NW George Town, ASFS V7020; 1.0 mi SE Moss Town, ASFS V7095; Stocky (Stocking?) Island, MCZ 13436 (type of *gibbus*), 13437 (paratype); cay off Roseville (Rolleville?), MCZ 13435 (paratype); **Little Exuma:** 5.7 mi SE The Ferry, ASFS V7045-50; Hog Cay, MCZ 55620; **Long Island:** MCZ 37957; Simms, CNHM 22744-47, MCZ 42278-79, 84396; Grays Settlement, ASFS V6812; 2 mi E Grays Settlement, ASFS V8613-28; Deadman's Settlement, UMMZ 117020; Clarence Town, MCZ 42280-81, UMMZ 117019 (2 specimens); **Rum Cay:** MCZ 6220 (type of *decoratus*); **Great Ragged Island:** UMMZ 118029.

The population of S. *decoratus* on Cat Island shows certain peculiarities of its own. Most notable is the greater degree of middorsal splitting of the collar (Fig. 4); this appears to be ontogenetic, and the majority of adult females show nearly complete division of the collar, which is a greater incidence than found in other populations of the species (the Bahaman races are the only ones in which the trend is present). Some specimens from Long Island and the Exumas show a trend in this direction, with that of Long being strongest. More complete collections may show a definable population to exist on Cat and the proximal northwestern end of Long (in the present sample greater splitting of the neck band appears to occur in the north). Of the six Cat Island males four are unspotted and two have some indication of spotting. This also suggests some divergence from the bulk of the material assigned to S. *d. decoratus*, but it is not conclusive. Body bands are 3/4 in 3 specimens, 4 in 20 specimens, and 4/5 in 2 specimens. This is a trend toward higher numbers of bands than is found in the other races. For the Cat Island specimens dorsals are 49-64, mean 54.8; ventrals 35-46, mean 40.1; midbody scales 70-85, mean 76.5; fourth toe lamellae 7-13, mode 10; internasals 1-4, mode 1; escutcheons 5-9 X 7-11.

Sphaerodactylus decoratus flavicaudus Barbour

Sphaerodactylus flavicaudus Barbour, 1904, Bull. Mus. Comp. Zool., 46:56. Type locality, Mangrove Cay, Andros Island; cotypes, MCZ 84385-95, 6953, 13564, UMMZ 107614.

Definition. A moderately sized race of *decoratus* characterized by 3 or 4 body bands, relatively light, not heavy and dark, bordered posteriorly by light punctulations; throats of females moderately to slightly marked; collar not prominently cleft middorsally; males unspotted.

Range. Known from the islands of Andros and South Bimini (Fig. 1); may be reasonably expected on the rest of the Bimini chain with the possible exception of North Bimini.

Variation. In 60 specimens, dorsals range from 46-66, mean 56.1; ventrals 31-42, mean 36.9; midbody scales 61-86, mean 73.6; fourth toe lamellae 8-13, mode 10; internasals 1-2, mode 1; upper labials 3-5, mode 4; escutcheon 6-8 X 7-13. Largest male and female 35 mm snout-vent.

Female coloration: Ground color gray to tannish-gray; bands wood brown with narrow, dark, not sharply distinct edges and bordered posteriorly by light flecks. Body bands 3 (8 specimens), 3/4 (13 specimens), or 4 (34 specimens). Collar black in juveniles, dark brown in adults with white ocelli, middorsal break lacking or not prominent. Ocelli of moderate size and prominence, sometimes present on first body band. A distinct but not boldly contrasting throat pattern is present in a few females, but in most the markings are faint or virtually lacking.

Male coloration: Dull brown; head, throat and tail pale yellow. None of the extensive series

of males of this form is spotted. Iris color in Bimini specimens was noted as "greenish-gray to silvery." (All above colors are from field notes on South Bimini specimens.)

Comparisons. *Sphaerodactylus d. flavicaudus* differs from *decoratus* primarily in having unspotted males. In scale characters there are no significant differences, except in the number of fourth toe lamellae which is modally 10 in *flavicaudus* and 12 in *decoratus*. The frequencies for the different categories of body banding are about the same in both. Female *flavicaudus* tend to have more prominent throat markings, but there is considerable overlap. On the basis of the Bimini material there appears to be an iris color difference, that of *flavicaudus* greenish gray to silvery and that of *decoratus* (Great Exuma) rich brown.

Specimens examined. "Bimini," AMNH 73489, 73493-96; South Bimini: western side, ASFS X4663-69, AMNH 76873, 68806 (2 specimens), 68807 (2 specimens), 68808 (2 specimens); western end, ASFS X4733-39, X4753-60, X4780-81, CM 34133; Andros: MCZ 6221, 84369; approx. 0.5 mi N of Nicholl's Town, ASFS V6966-71; west side Morgans Bluff, ASFS V6974-75; Mangrove Cay: MCZ 6952, 84375-84, 84385-95 (cotypes), 6953 (cotype), 13564 (cotype), UMMZ 107614 (cotype), AMNH 24715; Bastian Pt. on South Bight, UMMZ 117022; Pinder Village (not mapped), UMMZ 118028 (2 specimens); South Bight, Driggs Hill shore, UMMZ 117023 (2 specimens).

Sphaerodactylus decoratus atessares[2], new subspecies

Holotype. MCZ 81100, an adult female from 4 mi N, 2.3 mi E Rock Sound, Eleuthera, Bahama Islands, collected 5 October 1965 by Richard Thomas.

Paratypes. Bahama Islands, Eleuthera: ASFS 17557, Alicetown, native, 6 November 1961; AMNH 69245-46, 69249, Hatchet Bay, C. Campbell, 5 April - 17 July 1948; ASFS V6805-06, 6 mi N Tarpum Bay, R. Thomas, 3 October 1965; ASFS V6833-40, V 6842-54, same data as type; USNM 157895-902, MCZ 81101-09, same locality and collector as type, 7 October 1965; UF 21504-09, UIMNH 61651-58, CM 40586-90, ASFS V6946-53, same locality and collector as type, 9 October 1965; KU 93349-51, 1.5 mi E, 2.9 mi S Rock Sound, R. Thomas, 7 October 1965; KU 93348, 5 mi NNW Southeast Point, R. Thomas, 4 October 1965.

Associated specimens. New Providence: MCZ 6973; UMMZ 100741, Nassau, Ft. Charlotte; Rose Island: (near New Providence), UMMZ 117021.

Diagnosis. The largest subspecies of *decoratus*, characterized by possessing only three body bands, which are nearly solidly pigmented, have only a narrow light central zone, and are edged posteriorly by continuous narrow light areas instead of discrete punctulations; bands in juveniles solid, not lightened by faint light stippling.

Range. The island of Eleuthera, excluding the southern tip (Fig. 1); there are no specimens from north of Hatchet Bay; also New Providence and Rose Island, at least tentatively.

Description of type (Fig. 5). An adult female, 39 mm snout-vent length, total length 73 mm; dorsal scales, axilla to groin, 63; ventrals 37; midbody scales 77; 10 fourth toe lamellae; four labials to mid-eye on either side; two internasals. Median dark snout stripe present, slightly forked posteriorly, joins dark interocular area at level of posterior part of eyelid; head band black, slightly lightened centrally; collar nearly solid black with no median interuption, ocelli small, white; three body bands with wide dark margins and narrow, indistinct central light area; light outlines to dark bands give appearance of accessory indistinct dark bands in middle of interband areas. Faint small ocelli present on all body bands. Tail alternately banded with black and white; throat markings indistinct; venter light grayish.

Variation. In 60 paratypes dorsal scales range from 50-69, mean 58.6; ventrals 34-44, mean 37.9; midbody scales 64-88, mean 76.0; fourth toe lamellae 8-14, mode 10; internasals 1-3, mode 2; escutcheons compact as in the rest of the species, 5-9 scales long and 6-13 wide.

Female coloration: Most female paratypes are similar in color and pattern to the type. The most notable variant is a tendency toward fragmentation of the body pattern in some large specimens in which the dark areas are sharply set off, and the ground color lighter. Light flecks form a posterior border to the dark stripes instead of a continuous light edge in a few specimens, but the flecks are not so prominent and discrete as in other races. Small paired ocelli are found in all three body bands in about one-third of the specimens; others have ocelli in the first or second body band, and others in none. In life, females were noted as having a light gray to

[2]*atessares*, from Greek *a* (alpha privative = without, and *tessares*, four

gray-brown ground color, bands dark brown, variably hollowed with lighter brown; venters pinkish gray; tails banded black and white. Juveniles have the female coloration but the bands are solid except for the occasional presence of the minute paired ocelli, and the interbands are lighter, almost white, sometimes with a pinkish tinge, and with no central darkening; transition to adult coloration is gradual.

Male coloration: Males vary from completely unspotted to completely spotted; the ground color is brown to gray brown or light gray, with the heads dull yellow and tails usually somewhat brighter yellow. Iris color for specimens of *atessares* was noted as brown.

Comparisons. In possessing only three body bands *atessares* differs in a strongly modal manner from all other Bahaman races. The heavily pigmented body bands differ from those of the vast majority of specimens of the other races; the small, irregular and relatively sharply set off central light areas of the dark bands also differ from the more extensive light areas and narrower dark margins of the other forms. The collars of *atessares* show no tendency toward middorsal splitting as is found in at least some specimens of the other Bahaman forms, especially in the Cat Island population.

The discrete light flecks that form the posterior margins of the dark bands in the other Bahaman populations do not characterize *atessares*. Even where there is some indication of punctulations, the light border is more continuous and the flecks not so prominent as in the other subspecies. The solid banding and contrasting ground color of the juvenile *atessares* apparently is a constant difference, as the dark bands of the juveniles of the other Bahaman populations are stippled with light areas, and result in a hazier, less substantial appearance to the pattern. Although male *atessares* may be thoroughly covered with spots, they never seem to attain the neatness and regularity found in some spotted males of *decoratus*. *Sphaerodactylus d. atessares* exceeds all other members of the species in size, the maximum snout-vent length being 40 mm (six specimens). The maximum size for the other races varies but does not exceed 37 mm. The impression received when collecting the paratypes was that they were distinctly larger than other members of the species which had been collected. In scalation the differences are slight; the modal internasal condition of 2 differs from other races discussed except for the Long Island population of *decoratus*; the modal fourth toe lamellar count of 10 differs from that of *decoratus* (12) but not from *flavicadus*.

Eleven freshly collected geckos from the southern tip of Eleuthera (Southeast Point) are not assignable to *atessares*. The two males are unspotted and very pallid. Of the remaining specimens, three have four body bands, two have four bands on one side, and three have three bands. All (except the males) show the lighter body bands bordered posteriorly by light flecks which are not characteristic of *atessares*. The one adult female has a nearly completely divided collar. It is our belief that these specimens show the influence (apparently strong) of the Cat Island geckos immediately to the south.

Two specimens from New Providence and one from Rose Island near New Providence are provisionally referred to *atessares*. One of the New Providence specimens has three heavy dark body bands, the other is a juvenile in poor condition which has four bands. Little else can be determined. The Rose Island specimen has three bands but is not typical of *atessares* in all ways. Only additional material from these islands will show their true affinities.

Six specimens from Leaf Cay and one from Little Norman's Cay in the Upper Exuma chain (which closely approaches Eleuthera) may show the influence of *atessares*. They have three body bands and two internasals, and the one male is unspotted. Otherwise they bear no particularly close resemblance to *atessares*. They likely are the result of past genetic continuity with the Eleuthera race, and the resultant influence may extend some distance down the Exuma chain (see remarks under *S. d. decoratus*).

THE CUBAN SITUATION

Unfortunately for systematists, the city of Guantánamo in Oriente Province has the same name as the extensive bay to the south, which has in turn bestowed its name upon the United States Naval Base located at the mouth of the bay. The city is situated well inland (about 18 miles), nearly in the foothills of the Sierra del Guaso which here forms the southern margin of the mountainous interior of the province. To the south and slightly to the east of the city lies

the bay, extending about 13 miles inland in a north-northeasterly direction, and at its entrance occupying *both sides* is the U. S. naval base (although the main part of the Base is on the east side of the bay). The naval base, then, is at best (straight line distance) about 13 miles from the city, and such a path would necessitate cutting across the bay itself. Thus the naval base is a substantial distance from the city, and its principal part is on the opposite side of a very significant physical barrier.

To add to the general uncertainty of most herpetological collections from the region, in which people have in the past failed to distinguish a city from its surrounding countryside, we find that some (and fear that others) have not distinguished between the city, the bay, and the naval base bearing the name Guantánamo. For example, the type locality of *Sphaerodactylus alayoi*, as stated in the original description, is the naval base but the locality of the holotype as catalogued is "Guantánamo." There appears to be no simple way of determining the truth of the matter, for collections apparently were made by Grant at both the naval base and the city (*e.g.*, the type locality of *spielmani*, *fide* the original description is "Guantánamo"). To confuse matters further, virtually no collectors have made any effort to specify where on the naval base specimens were collected—an elemental consideration for anyone hoping to further scientific knowledge. It is probable that most collections labelled "U. S. Naval Base, Guantanamo Bay," or some such, came from the eastern side of the bay, but then one can never be sure. In situations such as we face in the present study, it would be most helpful to be certain. In conclusion, knowledge of the complex (and we do indeed mean complex) of sphaerodactyls occurring in the vicinity of Guantánamo must remain to a certain degree in confusion. Our results in some instances are tentative, and in such cases we will make ready reference to the state of affairs.

Barbour (1914) applied the first name to this complex of banded Cuban forms when he named *torrei*. His description of the type said that it had five dark transverse bands from snout to sacrum. Additionally, and perhaps most pertinent, he never figured the type but only other specimens that he presumed to pertain to this form. Thus, when Grant (1958) described *spielmani* he assumed the name *torrei* to apply to a three-banded (between axilla and groin, six from snout to groin) form as illustrated by Barbour (1921). Unfortunately the assumption was incorrect, the type and paratypes of *torrei* have two bands between the axilla and groin and pertain to the form to which Grant assigned the name *spielmani*. Thus *spielmani* is a junior synonym of *torrei*. With the more widespread three-banded form of Cuba we associate the name *S. decoratus*.

Sphaerodactylus decoratus granti, new subspecies

Holotype. BYU 17233, an adult female, collected at Banes, Oriente Province, Cuba, by Chapman Grant, January, 1958.

Paratypes. Cuba: Camagüey Province: MCZ 57339-43, 7 km S Playa Santa Lucía, R. Molina and R. Ruibal, 9 July 1957; MCZ 59316, 15 km S Playa Santa Lucía, R. Molina, E. E. Williams, R. Ruibal, 24 August 1959; Oriente Province: MCZ 36941-42, Las Calabazas, Holguín, S. Aguayo, 4 June 1923; BYU 17192-232, 17234-17268, 22889-22920, and two untagged juveniles, same data as type; AMNH 61404-10, Marcané, C. M. Jervis, 30 January 1930.

Definition. A race of *S. decoratus* characterized by moderate size, three uniformly colored, brown body bands with sharp dark edges and with prominent, dark-edged paired ocelli usually on each band; bands not prominently edged with light or with posterior light flecks; collar not black but colored like body bands; throats prominently marbled in the majority of specimens; males spotted.

Range. Presently known from extreme northeastern Camagüey Province, the northern half of Oriente Province whence it is presumed to follow areas of low or intermediate elevation around the western edge of the central Oriente mountains (Sierra de Nipe and its southern affiliates) to the vicinity of the city of Guantánamo (Fig. 6).

Description of type (Fig. 7). An adult female, 27 mm snout-vent, 51 mm total length; dorsals, axilla to groin, 51; ventrals 37; midbody scales 81; fourth toe lamellae 12, upper labials 4/4, one internasal. Coloration: Head, neck and three body bands brown with distinct dark edges; prominent dark-edged, paired, cream-colored ocelli present on neck band, and present but less prominent on 3 body bands; snout stripe complete, forked posteriorly, fading into dark interocular area; head coloration extending onto underside of head with band edges retaining their alignment but mixing centrally, resulting

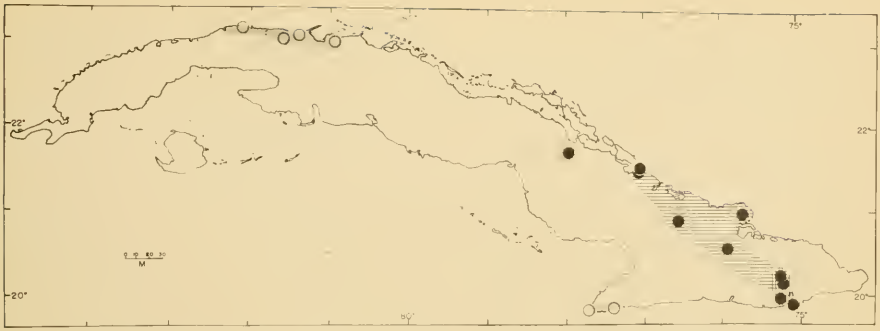


Fig. 6. Map of Cuba. Solid symbols indicate locality records for *Sphaerodactylus decoratus*, hollow symbols for *S. intermedius*. Ranges of subspecies of *S. decoratus* are as follows: *S. d. granti*, horizontal lines; *S. d. lissodesmus*, diagonal lines; *S. d. strategus*, vertical lines. Overlap of symbols of *granti* and *strategus* in the vicinity of Guantánamo indicates area of intergradation.

in prominent brown on cream marbling; ground color of body tan to pale, nearly cream; body bands narrowly outlined in light; tail banded with alternating dark-edged brown bands and tan interbands; venter cream, faintly stippled with dark pigment.

Variation. Of the 51 specimens counted dorsal scales are 47-66, mean 56.3; ventrals 29-41, mean 35.0; midbody scales 69-89, mean 78.1; fourth toe lamellae 7-13, mode 10 or 11; internasals 0-2, mode 1; escutcheons 5-10 X 8-17. The largest specimens of both sexes are 32 mm snout-vent.

Female coloration: The other female specimens are very similar to the type in coloration. There is some variation in intensity of the dark edges to the bands, and some have accessory dark spotting in the bands. Ocelli occur on the neck bands and all three body bands in over half of the specimens; in the rest of the ocelli usually occur as far posteriorly as the second body band. No adult specimen and few juveniles are without some indication of ocelli on at least the first two body bands. Throat patterns are prominent in all but a very few specimens, and in those they are indicated. As is typical of the species, juvenile patterns are more solid, and hatchlings appear banded black and white.

Male coloration: Adult males are spotted; spots vary in size, some large or distinctly smaller and more numerous; most are fully spotted dorsally, but a common variant is the lack of spotting on the head. Variation in degree of spotting includes a few which are sparsely spotted and five which have no spotting at all. These five are all part of a series (BYU 22927-41) which was catalogued at a later time than the balance of the specimens, and all of this series are badly dessicated. It is evident that their history has in some way been different from the other specimens. The incidence of unspotted individuals (5 out of 15) compared to no unspotted specimens among the other northern Oriente males (37 specimens) throws further doubt on these specimens. Additionally, the series in question immediately follows in the catalogue a series of six (BYU 22921-26) also much dessicated *S. notatus*, whose locality is given as Guantánamo. Thus, we regard this series of males supposedly from Banes with high suspicion and believe that their locality is probably Guantánamo.

Comparisons. From *decoratus* and *flavicaudus*, *granti* differs in having only three body bands (versus a mode of four), and in having the bands more distinctly dark edged and more regular in outline. In *granti* there is a lack of the hazy aspect of the pattern of these two Bahaman races and the punctulate posterior border to the body bands. The ocelli are more frequent and more prominent in *granti* and the collars are never solid black as they often are in all of the Bahaman races. The boldness of the throat pattern is also greater in *granti*. *Sphaerodactylus d. granti* is distinctly smaller than the Bahaman races but the contrast with *atessares* is most striking. In *atessares* there are heavily darkened margins to the body bands with smaller and irregular light centers as opposed to the wide, lighter bands with distinct narrow dark edges of *granti*.

Sphaerodactylus decoratus lissodesmus, new subspecies

Holotype. MCZ 57344, Sierra de Cubitas near Banao, Camaguey Province, Cuba, collected 22 August, 1957 by R. Molina and R. Ruibal.

Paratype. MCZ 57345, same data as type.

Definition. A race of *S. decoratus* characterized by having three light brown body bands with dark brown edges fading into the color of the band, not abruptly set off from it; ocelli indistinct or lacking, head band joined or approximated to dark facial area by two or three "bridges" of pigment near the dorsal midline; posterior light interband of the head distinctly wider than the central head band; snout region not heavily pigmented and extending onto underside of head along margin of lower jaw instead of to midline. Males unspotted.

Range. Known only from the Sierra de Cubitas in Camaguey Province, Cuba (Fig. 6).

Description of type (Fig. 8). An adult female 29 mm snout-vent; tail missing; dorsal scales, axilla to groin, 53; ventrals 33; midbody scales 84; fourth toe lamellae 11; upper labials 4/4, one internasal. Coloration. Ground color pale tan, three body bands brown, smooth edged and with narrow dark edges that fade gradually into wide central area of bands; collar with heavy dark edges that fade into a light center, and with one small, not dark-edged ocellus on the right side. Facial pattern much simplified; loreal and median snout stripes join in the midline at a level posterior to the eyes and form an elongate trident-like figure with a short posterior spire that nearly meets the dark head band, which in turn has two small anterior projections on either side of the spire; light interband on head and neck wider than dark head band; snout pattern not extending toward midline of underside of head but ending along the sides of the lower jaw.

Variation. The single paratype, a male, is attaining the unicolor phase; a faint pattern, much like that of the female, is yet evident; the trident-like cephalic figure is present, but the spire and the projections of the head band connect both elements instead of just approximating them. Dorsal scales, axilla to groin, 49; ventrals 36; midbody scales 79; fourth toe lamellae 12; labials 4/4; internasals 2; escutcheon evident but not fully developed; snout-vent length 30 mm.

[1]*lissodesmus*, from Greek *lisos*, smooth, and *desmos*, band

Figs. 7-10. Fig. 7. *Sphaerodactylus decoratus granti*, female, dorsal view; BYU 17233, holotype, Banes, Oriente Province, Cuba. Fig. 8. *S. d. lissodesmus*, female, dorsal view; MCZ 54344, holotype, Sierra de Cubitas near Banao, Camaguey Province, Cuba. Fig. 9. *S. d. strategus*, female, dorsal view; MCZ 81110, holotype, east side of the Bahia de Guantánamo, United States Naval Base, Oriente Province, Cuba. Fig. 10. *S. alayoi*, female, dorsal view, USNM 44219, paratype, U. S. Naval Base, Guantánamo, Oriente Province, Cuba.

Comparisons. Although only two specimens assignable to *lissodesmus* are available, they are so different from the other races of *decoratus* that we have little doubt that they represent a distinct form endemic to the limestone massif of the Sierra de Cubitas. The complex head pattern joining the facial markings and head band serve to distinguish *lissodesmus* from all other subspecies. The smooth-sided and distinctly colored body bands are not found, although rarely approached, in the other races. The slight extent of the facial pattern onto the throat is also distinctive and in contrast to the Bahaman specimens, which frequently have a very faded, virtually absent throat pattern. The single male is unspotted, and if this is true for the population, *lissodesmus* is additionally distinct from its nearest geographical relative *granti*, which has spotted males.

Sphaerodactylus decoratus strategus[4], new subspecies

Holotype. MCZ 81110, an adult female from the east side of the Bahía de Guantánamo, United States Naval Base, Oriente Province, Cuba, collected 24 April 1965, by Richard Thomas.

Paratypes. MCZ 81111, USNM 15903-04, ASFS V6244, V6246-47, same locality as type, 23 April 1965, R. Thomas, native; ASFS V6256-60, V6262, same data as type; ASFS V6275, same locality as type, 25 April 1965, R. Thomas; MCZ 68732, 69441, same locality as type, R. V. Lando, June 1962 and August 1958; UIMNH 44232, same locality as type, A. Spielman, January 1958.

Associated specimens. USNM 59221-31, Caimanera, Oriente Province, Cuba.

Definition. A race of *decoratus* closely allied to *granti* in possessing three wide body bands with narrow black margins, but differing from that form in that the males are unspotted.

Range. The south Oriente coast, possibly only that part to the east of the Bahía de Guantánamo (Fig. 6); presumed to intergrade with S. *d. granti* in the vicinity of the city of Guantánamo.

Description of type (Fig. 9). An adult female, 32 mm snout-vent, total length 60 mm. Dorsal scales, axilla to groin, 64; ventrals 42; midbody scales 84; fourth toe lamellae 11; upper labials 3/4; one internasal. Coloration: Three wide body bands bordered with a sharply distinct narrow dark margin; ocelli present on collar and indistinct on first two body bands; head band wide, only narrowly separated from collar and facial markings; snout stripe entire, forked posteriorly and connected with interocular dark area; head band continues across throat as do the facial markings; collar interrupted in midline of throat; tail banded with broad dark and narrow light bands. (For color in life see below.)

Variation. Dorsal scales, axilla to groin, 50-67, mean 59.1; ventrals 33-42, mean 36.8; midbody scales 73-84, mean 78.3; fourth toe lamellae 8-13, mode 11; escutcheons 7-10 X 8-23. Female coloration is much the same as that of the type; one specimen has a split body band on one side giving a 3/4 formula. Specimens were noted in life as having the dark bands dark brown or gray-brown, light interbands tan or light gray or gray-brown; ocelli white; venter gray, light bands on throat cream; light bands near tip of tail white. Iris color dark brown. Males were noted as having the dorsal coloration gray or blue-gray with faint lighter flecking evident, sometimes outlining the banded "female" pattern. Heads were dark dull yellow, tails yellow to dark yellow-green; venters light gray; throats and tails dull yellow beneath. Iris color gray to gray-brown.

Comparisons. The female coloration of this form is closest to that of *granti* on the north coast. There appears to be an at least average greater width of the body bands in *strategus*. Grant (1959a) commented that the south coast "*torrei*" (=*decoratus* as used herein) was lighter in color than those on the north coast. This is probably correct but cannot be verified in the preserved specimens. The specimens from the city of Guantánamo that are assignable to *decoratus* (see below, specimens not subspecifically allocated) are considered to be intergrades between *granti* and *strategus*, as they include both spotted and unspotted males. The associated specimens from Caimanera on the west side of the bay are only tentatively referred to *strategus* because of geographical proximity; there are no males in the series to allocate them definitely. Otherwise, the comparisons of *strategus* are for all practical purposes the same as those of *granti*.

The paucity of specimens of S. *decoratus* from the southern coast of Oriente is strange, and it is possible that the primary distribution of the species in this region is to the east of the

[4]*strategus*, from Greek: *strategos*, admiral

Bahia de Guantánamo. Although there are specimens from Caimanera on the west side of the bay, there is no evidence of the occurrence of *S. decoratus* any farther to the west. The only Grant specimen of *strategus* that we know of is one that was included in the type series of *S. alayoi*. The fact that Grant collected other forms but apparently not many *decoratus* on the Naval Base may indicate that he collected in a different ecological situation than that preferred by *decoratus*.

Specimens Not Allocated to Subspecies

Specimens examined but not subspecifically allocated. *S. decoratus*: **Bahamas: Exuma Cays,** Leaf Cay, AMNH 76238-43; Little Norman's Cay, MCZ 13478; Eleuthera, Southeast Point, ASFS V6812-17, V6818-22; **Cat Island:** Orange Creek, Arthur's Town, MCZ 39556-62; Orange Creek, 1.5 mi NW Arthur's Town, UMMZ 79444 (5), 79445 (4); Arthur's Town, MCZ 39546-55; The Bight, ASFS V2138-39. *S. decoratus granti* X *strategus*: **Cuba, Oriente Province:** Guantánamo, BYU 17183-91, ?22927-41, USNM 59004, 63218, MCZ 8508, 13482-83, UMMZ 90632; Guantánamo, Monte Libano, MCZ 14665.

Sphaerodactylus alayoi Grant

Sphaerodactylus alayoi Grant, 1959, Herpetologica, 15(1):49. Type locality, Guantánamo Naval Base, U.S.N., Oriente, Cuba; type specimen, UMMH 44215.

Definition (males have not been included in the computations for reasons that will become apparent). Dorsal scales swollen, granular to imbricate above, becoming erected and papillate on the posterior flanks; faint keeling present in adult specimens; dorsals, axilla to groin, 53-60, mean 55.8 (23 specimens); ventral scales smooth, flattened, rounded and imbricate, 32-39 axilla to groin, mean 35.9 (20 specimens); midbody scales 73-82, mean 76.4 (21 specimens); scales of tail acute to rounded, smooth, flattened, imbricate, enlarged in midventral line; fourth toe lamellae 6-11, mode 10; internasals 1-2, mode 1; upper labials to mid-eye 3-5, mode 4; escutcheon large, compact, roughly triangular and with no extension onto thighs (5-8 X 9-12); habitus stout, snout moderate in length and width; size moderate, to 32 mm snout-vent.

Female coloration (Fig. 10): Pattern banded with three bands between axilla and groin; dark body bands twice or only slightly more than twice the width of light (cream to tan) interbands; dark bands sharply demarcated with wide dark borders and relatively narrow light central portions, no dark spotting or dark-edged ocelli present, ocelli usually present in neck band, not prominently dark-edged, transversely elongate; ocelli seldom present in body bands, not conspicuous and not prominently dark-edged, and tending to be transversely elongate; neck and head bands generally darker and more solid than body bands; loreal and median snout stripes present, snout stripe joining interocular dark area; ventrally, head stripes (including dark area anterior to eyes) usually continue across throat; neck stripe interrupted, or with only anterior dark edge continuing across throat. Young have solid bands as in other members of this group. Males which are assigned to this form are becoming unicolor but have some banded pattern remnants; others show some degree of spotting.

Range. Reported only from the type locality (Fig. 11).

Remarks. The status of *S. alayoi* is more questionable to us than that of any of the other species. There is no doubt whatsoever that the female coloration of this lizard is eminently distinct from that of *S. decoratus* which it resembles most closely. Included in the type series was one

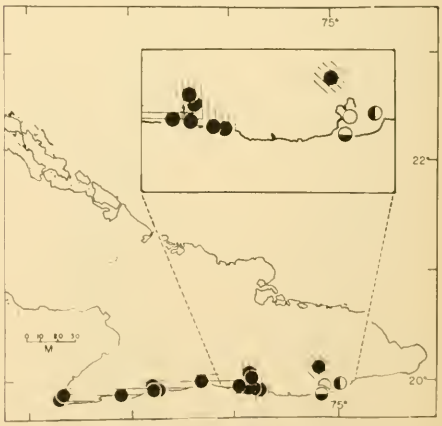


Fig. 11. Map of eastern Cuba with detailed inset of the region between the Bahia de Santiago and the Bahia de Guantánamo. Solid symbols indicate locality records for *Sphaerodactylus torrei*, hollow symbol for *S. alayoi*, vertically semisolid symbol for *S. ruibali*, horizontally semisolid symbol for *S. ruibali* + *S. alayoi*. Subspecies of *S. torrei* are as follows: *S. t. torrei*, vertical lines; *S. t. ocujal*, horizontal lines; *S. t. spielmani*, diagonal lines.

female (UIMNH 44232) which we consider to be a specimen of *decoratus* and not an *alayoi*. Males are less easily identifiable but remnant patterns do seem to ally them with the females. We have assigned two additional male specimens (MCZ 69438, 69440) to *alayoi* on the basis of their resemblance to the male paratypes.

It is possible that *alayoi* is a local pattern variant (it has been found nowhere else) or a very circumscribed race of *S. decoratus* in the region of the Bahía de Guantánamo (see Thomas and Schwartz, 1966, on *S. beattyi*). Obviously we are at a distinct disadvantage in dealing with *alayoi*, for we have not seen it in the field or in life. Unfortunately neither ecological information regarding the type series nor a statement of other species collected with the type series was given. We do not know if specimens of *decoratus* were found syntopically with *alayoi*, whether all specimens of *alayoi* were found together at one precise locality (the U.S. naval base is too big to be so considered), or if found in a variety of places with *decoratus*, ecologically separate, or whatever. Information on any of these points could influence our decision. Only carefully documented collecting and field observation will determine the truth.

Specimens examined. Cuba, Oriente Province: UIMNH 44215 (type), U.S. Naval Base, Guantánamo, November, 1957, C. Grant; UIMNH 44216-31, 44233-38, MCZ 61230-31 (female paratypes), U.S. Naval Base, Guantánamo, January, 1958, Andrew Spielman; UIMNH 44240-44 (male paratypes), data same as preceding; USNM 81822-23, Boquerón. Questionably referred: MCZ 69438, 69440, U.S. Naval Base, Guantánamo.

Sphaerodactylus torrei Barbour

Sphaerodactylus torrei Barbour, 1914, Mem. Mus. Comp. Zool., Harvard, 44(2):260. Type locality, Santiago de Cuba, Oriente Province, Cuba; type specimen, MCZ 6916.

Definition. Dorsal scales small, granular, serried, swollen, erect (especially on sides where the appearance is papillate), and weakly to strongly imbricate; faint keeling present in a few specimens; dorsals, axilla to groin, 45-59; dorsal scales with few large hair-bearing scale organs (3 hairs) on posterior face of scale. Ventral scales (including those of throat and chest) smooth, flattened, acute to rounded and imbricate (axilla to groin, 29-39); midbody scales 68-82; scales of tail acute to rounded, smooth flattened, imbricate, enlarged in midventral line; fourth toe lamellae 8-15. Internasals 0-2, mode 1; upper labials to mid-eye, 3-6, mode 4. Escutcheon large, compact, roughly triangular and with little extension onto thighs (6-12 X 9-27). Habitus stout, snout relatively long and narrow; size large, to 38 mm snout-vent.

Female coloration: Ground color light tan or gray; dark crossbands (2-3 axilla to groin, 4-5 snout to groin) solid or lightened centrally but not with well defined dark edges, ocelli when present small and not dark edged; narrow light fringe around dark bands sometimes present. Head dark to just behind eyes, light areas outline loreal and snout lines, the latter being either complete to interocular dark area or shortened and not joining interocular area; wide head band present with ear centrally positioned; neck band without ocelli or with more than two very small ocelli, not prominently outlined in black. Dark bands typically end abruptly on underside of throat or continue completly across; they do not fade out or meet to form an extensive marbling; dark color on snout represented beneath by a small but distinct mental spot. Venter light, tail banded like body.

Male coloration: Unicolor gray to tan on body; head and tail yellow; venter tan.

Range. The south coast of Oriente Province, Cuba, from the city of Guantánamo to the vicinity of Cabo Cruz (Fig. 11). Barbour and Ramsden (1919:120) referred to a specimen of *torrei* from Cotorro, which is near La Habana. We have not seen the specimen (it was received by Ramsden and may be in a Cuban collection), but it was in all probability a well-patterned specimen of *intermedius*. The same statement applies also to a *"torrei"* from Camoa (Barbour and Ramsden, *op. cit.*:85).

Remarks. In assigning the southwestern Oriente three-banded geckos to *torrei* (instead of *decoratus*), we may be accused of being arbitrary or of constructing a flimsy and artificial taxonomic edifice. Certainly, without the three-banded population, *S. torrei* would stand as a grossly distinguishable form with but two body bands, and such may be eventually found to be the truth. However, we were led to our conclusion by the facts that (1) there are no unquestionable specimens of *decoratus* (*i.e.*, females) either to the east in the fairly well collected region of Santiago, or to the northeast, either of which might indicate a link with the known Cuban populations of *decoratus;* (2) as discussed below the three-banded specimens are similar in several respects (coloration and modality of

scalation) to other *torrei*, and (3) number of body bands is not necessarily species constant.

It is possible that *S. decoratus* and *S. torrei* (or parts of them) are both members of one species, as their ranges are largely allopatric. This is a possibility that we cannot deny with complete certainty. However, on the basis of presently known localities (imprecise though they may be) there is a slight amount of east-west overlap and apparent sympatry at the city of Guantánamo, in which area the two are eminently distinct. It is the western three-banded race which causes the most doubt. As we have defined it, *S. torrei* is distinguishable from *S. decoratus* by its solid body and neck banding, not lightened centrally or dark edged, and ocelli, when present, small, simple, and not dark-edged; and by the very simple throat patterns in which the head banding extends onto the throat but remains discrete and boldly contrasting, and does not fade out or meld into an irregular mottling. Other less precisely enumerable differences in habitus and in trends of scalation (*i.e.*, dorsal scales of *torrei* tend to be more erected and closely packed) appear to exist.

Sphaerodactylus torrei torrei Barbour

Definition. A subspecies of *S. torrei* characterized by having two dark body bands wider than the light interspaces, a high frequency of dorsal keeling in adults, a long median snout stripe extending from tip of snout to interocular dark area, and a high modal number of fourth toe lamellae.

Range. Along the south Oriente coast from the vicinity of Santiago de Cuba east at least to Playa Juraguá (Fig. 11).

Variation. In 22 specimens, dorsal scales, axilla to groin, 45-49, mean 52.6; ventrals, axilla to groin, 31-37, mean 35.3; midbody scales 68-83, mean 74.3; some degree of dorsal scale keeling occurs in 25 of 27 adults. Internasals 0-2, mode 1; upper labials (in series from each side) to mid-eye 4 (50), 5 (23), or 6 (1) (number of labial series in parentheses). Escutcheons 6-10 X 9-21.

Female coloration (Fig. 12): All patterned specimens (21) have all dark (black) bands wider than light interspaces, and median dark snout stripe joined with dark interocular areas. Dark bands of most adults hazily and irregularly hollowed, outlined by faint light fringe. Neck band continues across throat in most specimens, posterior head band broken ventrally in most, and band at eye level discontinuous across throat and ends abruptly; dark chin spot extends posteriorly to include first lower labial.

Male coloration: Gray to tan on body; head and tail yellow or yellowish.

Specimens examined. Oriente Province: AMNH 83594-96 (6 specimens), AMNH 94260 (2 specimens), AMNH 94261, AMNH 94263, 4 km N Santiago de Cuba; MCZ 6916 (type), MCZ 84370-71 (paratypes), MCZ 84372-74, MCZ 6917, MCZ 19771, AMNH 42546, AMNH 42583-90, UMMZ 90728-29, UMMZ 90631, Santiago de Cuba; UMMZ 90724 (2 specimens), Santiago de Cuba, Church of San Francisco; AMNH 17721, Siboney; AMNH 94262 (3 specimens), Playa Juraguá, 3.7 mi E Siboney.

Sphaerodactylus torrei ocujal, new subspecies

Holotype. USNM 138015, an adult female, collected at Ocujal, Oriente Province, Cuba, by J. D. Hardy, 31 August 1956.

Paratypes. Cuba, Oriente Province: AMNH 32301, Belie, no collector, no date; USNM 138017, 5 mi N Cabo Cruz, J. D. Hardy, 6 September 1956; UMMZ 90727, 4 mi N Cabo Cruz, A. Vanderhorst, January, 1939; USNM 81827-28, Puerto Portillo, P. Bartsch, 29 August 1930; MCZ 42487, coast S of Pico Turquino, P. J. Darlington, June 1936; MCZ 50152, 84397, near Pico Turquino, J. Acuña, 10-19 June 1936; USNM 138016, 1 mi E Ocujal, J. D. Hardy, 31 August 1936; USNM 29759, Guamá, B. S. Bowdish, 2 January 1902.

Associated specimens. Cuba, Oriente Province: UMMZ 90725, Santiago de Cuba, La Socapa; UMMZ 90726, Santiago de Cuba, Morro Castle.

Definition. A subspecies of *S. torrei* characterized by having three dark bands only slightly broader than light interspaces between axilla and groin; numerous, very small, not dark-edged, ocelli in dark bands of adults; median dark snout line not extending to interocular dark area; male coloration spotted; dorsal keeling absent in most specimens.

Range. From the vicinity of Cabo Cruz east at least to Guamá and probably to the coast southeast of the city of Santiago de Cuba (Fig. 11).

Description of type (Fig. 13). An adult female with snout-vent length of 33 mm, tail missing. Dorsals, axilla to groin, 52; ventrals, axilla to groin, 35; midbody scales 73; fourth toe lamellae

Figs. 12-14. Fig. 12. *Sphaerodactylus torrei torrei*, female, dorsal view; MCZ 6916, holotype, Santiago de Cuba, Oriente Province, Cuba. Fig. 13. *S. t. ocujal*, female, dorsal view; USNM 138015, holotype, Ocujal, Oriente Province, Cuba. Fig. 14. *S. t. spielmani*, female, dorsal view; MCZ 61233, paratype, Guantánamo, Oriente Province, Cuba.

10; internasal 1; 4 supralabials to mid-eye. Dorsal scales granular (more so middorsally), only slightly imbricate, swollen but not erected, and keeled only in sacral region; gular, chest and ventral scales smooth.

Coloration: Median dark snout stripe extends to level with anterior border of orbits; loreal stripes present, dark band at level of eyes unbroken medially; posterior head band relatively narrow, about width of light interspace, hollowed centrally by light suffusion, and with ear centrally positioned. Neck bands and three body bands dark brown, approximately same width as light interspaces, suffused with lighter brown centrally, and bearing numerous small, not dark-edged, ocelli. Dorsal ground color brown, lighter at margins of dark bands. Ventrally a U-shaped dark spot is confined to mental, followed on either side by another dark spot occupying central half of first lower labial; dark band at eye level extends onto throat and broken medially in abrupt (not fading) termination; posterior head band continues across throat, neck band does not, and terminates abruptly, as do body bands, on ventrolateral surfaces; appearance of fading is given by central light suffusion.

Variation. Dorsals, axilla to groin (5 specimens), 48-54, mean 51.2; ventrals, axilla to groin (4 specimens), 32-36, mean 34.5; midbody scales (5 specimens) 73-79, mean 75.5; fourth toe lamellae 9-14, mode 13; internasals 1-2, mode 1; supralabials 3 (2 labial series) or 4 (20 labial series); escutcheons 7-9 X 9-12. Coloration of four adult female paratypes similar to that of type; median snout line of one (USNM 81828) touches interocular dark zone by virtue of thin spire-like extension, but is not broadly confluent therewith; second chin spots lacking in USNM 29759, but mental spot entirely covers mental and extends onto first labial. One specimen (MCZ 42487) has somewhat scrambled but still recognizable body pattern. Juvenile specimens have very solid bands and lack ocelli, as is characteristic of juveniles of other forms of this group. Extent of ventral banding described for type similar in other specimens, although neck band continuous across throat in one and eye-level band in another. Males are spotted with relatively small, dark brown spots; two specimens transitional from juvenile pattern to spotted condition, and faint but complete basic patterns agree in detail with female pattern described. One specimen (MCZ 84397) has unicolor head, and of two provisionally referred specimens one (UMMZ 90725) has only head spotted, body unicolor. These two specimens will be discussed below.

Sphaerodactylus torrei spielmani Grant

Sphaerodactylus spielmani Grant, 1958, Herpetologica 14(4):225. Type locality, Guantánamo, Oriente Province, Cuba, type specimen UMNH 44105.

Definition. A subspecies of *S. torrei* characterized by having dark transverse bands narrower (approximately half as wide) than the light interspaces, and only two between axilla and groin; median snout-stripe typically short, never joining interocular dark area; eye-level band reduced, not continuous across head in most specimens, males unicolor; dorsal keeling lacking in majority of specimens, and low modal number of fourth toe lamellae.

Range. Known only from the city of Guantánamo but assumed to meet and intergrade with *S. t. torrei* somewhere between Playa Juraguá and Guantánamo (Fig. 11). The species is not known from the U.S. Naval Base, as far as we know, and whether it ranges to the east of the city of Guantánamo is unknown.

Variation. In 50 specimens, dorsal scales, axilla to groin, 43-59, mean 53.7; ventrals, axilla to groin, 29-37, mean 33.3; midbody scales 68-79, mean 73.0; fourth toe lamellae 8-15, mode 10; internasals 0-1, mode 1; upper labials to mid-eye 3 (five labial series), 4 (121 series), 5 (98 series), 6 (6 series). Escutcheons 6-12 X 11-24. The largest specimen is a male that measures 38 mm snout-vent length.

Female coloration (Fig. 14): Females generally as diagnosed. Some have lightened centers to bands or irregular light spots within them; there may be tendency toward further reduction of body bands, as some specimens have one or more of these broken, reduced, or incomplete. About 88 percent have eye-level band incomplete across head, some specimens have ventral portion of band disjunct from dorsal portion, in some this leaves only narrowly circumorbital dark area. Roughly half of specimens have no first infralabial spot; some have this spot joined by narrow extension with ventral ends of eye-level band; many of those which have no first labial spot have slight anterior extension of eye-level band. Thus the loss of that spot appears to involve fusion with the eye-level band.

Males are unicolor tan to gray brown in their final adult coloration.

Comparisons. *Sphaerodactylus t. torrei* is distinguished from *ocujal* by the possession of two, rather than three, body bands, by having the median snout stripe confluent with the dark interocular region (Fig. 15), by lacking ocelli in the bands, by having unicolor rather than spotted males, and by having the mental spot fused with the first labial spot. *Sphaerodactylus t. spielmani* differs from *torrei* in having the dark bands much narrower than the light interspaces (rather than distinctly wider) and in having the median snout-stripe short and not connected with a dark interocular area (Fig. 15); in lacking keeling in most specimens *spielmani* differs modally from *torrei*, at least; it also differs from both *torrei* and *ocujal* in having a modal number of fourth toe lamellae of 10 rather than 13. *Sphaerodactylus t. ocujal* differs from both the other races in possession of three rather than two body bands. The reasons we have included it in *torrei* in the absence of obviously intergradient specimens have been stated in the discussion of the species. Additionally, we felt that our conviction of relationships of the forms should be expressed trinomially rather than by proposing another species for a region that has already had described from it a plethora of species.

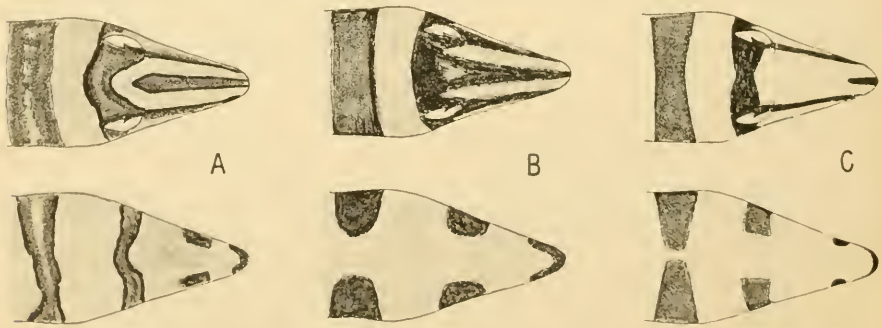


Fig. 15. Dorsal and ventral views of heads of three subspecies of *S. torrei*: A, *S. t. ocujal*, MCZ 42487; B, *S. t. torrei*, AMNH 42586; C, *S. t. spielmani*, UMNH 44212.

In some respects (shortened snout stripe, the modal presence of a separate first lower labial spot, and modal lack of keeling in both forms) *ocujal* and *spielmani* are more similar to one another than to *torrei*. The two male specimens provisionally referred to *ocujal* are of interest because of their proximity to Santiago de Cuba, the locality for many of the *torrei* examined. Both are from the mouth of the Bahía de Santiago. One of them lacks spotting except on the head, and it may be that this region is an area of intergradation between the two forms. The bay would not necessarily be an absolute barrier at its mouth (which is very narrow), because the region has evidently been in a state of geological flux and different channels have probably existed as mouths to the bay at different times in the relatively recent geological past. Therefore an area of intergradation *could* exist in a region encompassing both sides of the mouth of the Bahía de Santiago. Whether it does or not, only more specimens will demonstrate.

Specimens examined. Cuba, Oriente Province: UIMNH 44105 (type), 44106-45, 44152-213, MCZ 61232-33; BYU 17165-6 (paratypes), MCZ 59142-46, USNM 140270-73, Guantánamo.

Sphaerodactylus stejnegeri Cochran

Sphaerodactylus stejnegeri Cochran, 1931, Copeia, no. 3, p. 90. Type locality, San Michel, Dépt. du Nord, Haiti (here amended to St. Michel de l'Atalaye, Dépt. de l'Artibonite); type specimen, USNM 76640.

Definition. A *Sphaerodactylus* of the *decoratus* group characterized by having dorsal scales flattened to slightly swollen, smooth, rounded, and slightly imbricate; head granules relatively large and cobble-like, not small and tending toward conical; dorsals with few large hair-bearing organs on tip of scales; dorsals, axilla to groin, 41-52, mean 47.0; ventrals smooth, flattened, rounded, and imbricate (axilla to groin, 27-36; mean, 31.1); scales around midbody 53-65, mean 57.7; dorsal scales of tail smooth, flat-lying, rounded and imbricate; scales beneath tail smooth, rounded, imbricate and enlarged midventrally. Internasals 1-2, mode 1; upper labials to mid-eye 4 or 5 in one labial series; escutcheon relatively large, compact and with extensions well onto thighs (4-7 X 15-22; one specimen has an escutcheon width of only 7 scales). Habitus moderate to slender, snout moderate in length and breadth but sharply pointed; size moderate, to 31 mm snout-vent in males, 30 mm in females.

Female coloration (Fig. 16): Dorsal ground color light gray to gray-brown, irregularly spotted or mottled with brown; two solid black body bands, very narrow and widely spaced, and outlined with white margins; neck band solid black, somewhat wider than body bands, outlined in white, extending onto throat and usually ending ventrolaterally, but may extend completely across; tail banded with dark bands similar to those of body; head pattern simple and distinct: one relatively wide dark band anterior to ear joined broadly on each side by wide postocular dark stripe that continues anterior to eye as wide loreal stripe to tip of snout; venter light, cream to grayish.

Male coloration: Unicolor tan or yellowish tan above, venter as in females. (Coloration given here is from preserved specimens.)

Range (Fig. 17). As presently known, Haiti, from St. Michel de l'Atalaye west to St. Marc (Mertens, 1939:42), thence south to the Cul de Sac Plain (it is not known from the Dominican Valle de Neiba). The record from "southwestern Haiti" (Cochran, 1941:112) cannot be taken too precisely; the specimen was originally cited as being from "Haiti" (Cochran, 1924:3).

Remarks. We have amended the type locality because there appears to be no San Michel in the Département du Nord, and because the collectors of the type, A. J. Poole and W. M. Perrygo, visited St. Michel de l'Atalaye in December of 1928 (Wetmore and Swales, 1931:36) when the type was collected.

Fig. 16. *S. stejnegeri*, female, dorsal view; MCZ 63173. Eaux Gaillées, Dépt. de l'Ouest, Haiti.

Fig. 17. Map of Haiti. Solid symbols indicate localities whence specimens of *S. stejnegeri* have been examined, and the hatched area indicates the conjectural range of the species. The northeastern extension of the hatching includes the type locality whence we have not examined material.

Specimens examined. Haiti: Dépt. de l'Artibonite: MCZ 59478-87, bridge over Rivière de l'Artibonite, St. Marc Road; **Dépt. de l'Ouest:** MCZ 13481, Thomazeau; MCZ 52158-62, Hatte Lathan, Cul-de-Sac Plain; MCZ 59488-94, 63172-73, 84353, YPB 3089-90, Eaux Gaillées; MCZ 13442, Coutard.

Sphaerodactylus intermedius Barbour and Ramsden

Sphaerodactylus intermedius Barbour and Ramsden, 1919, Mem. Mus. Comp. Zool., 47:211. Type locality, Sierra de Hato Nuevo between Hato Nuevo and Sabanilla de la Palma, Matanzas Province, Cuba; type specimen, MCZ 12305.

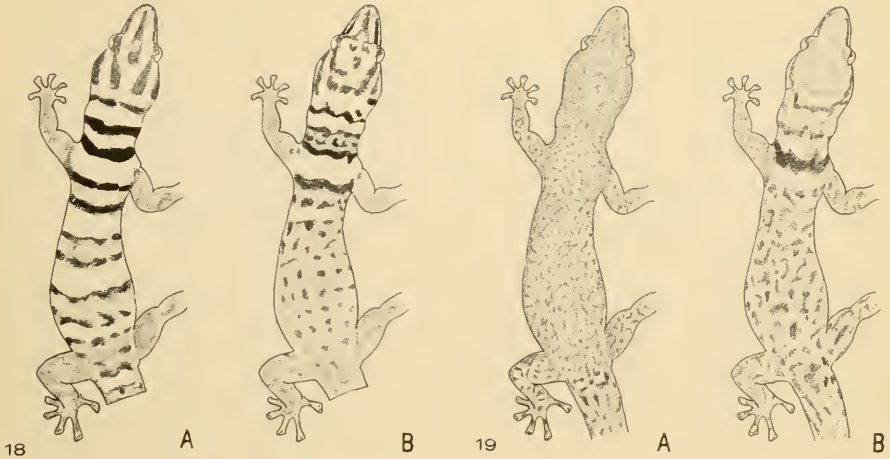
Sphaerodactylus decoratus drapetiscus, Schwartz, 1958, Proc. Biol. Soc. Wash., 71:29. Type locality, 2 mi E Playa de Guanabo, Cueva de Rincón de Guanabo, Habana Province, Cuba; type specimen, AMNH 77759.

Definition. A *Sphaerodactylus* of the *decoratus* group having the dorsal scales granular and juxtaposed to swollen, rounded and slightly imbricate but not prominently erected and papillate; weak keeling present in most specimens. Dorsal scales with few large hair-bearing scale organs on posterior face of scales, dorsals, axilla to groin, 49-62; ventrals 31-44; midbody scales 65-77. Dorsal scales of tail smooth, flat-lying; ventral scales of tail smooth, enlarged, but apparently not prominently so in midventral line. Internasals 0-2, mode 1; upper labials to mid-eye 4 or 5, mode 4; escutcheon large, compact, roughly triangular and with virtually no extension onto thighs, 6-8 X 8-11. Habitus moderate, snout elongate, size large, to 35 mm snout-vent.

Female coloration (Fig. 18): Head band and facial markings united to produce dark head markings that end just behind ear; two dark-edged light postocular stripes, one (inferior) that proceeds diagonally onto ventrolateral surface of throat, fading out on a level with ear, and one (superior) proceeds diagonally upwards and over temporal area, and at least in its "basic" manifestation turns medially and joins its mate on opposite side, forming a U-shaped light cephalic figure; loreal and median snout stripes present, latter forked posteriorly before joining interocular area; collar present, heavily dark-edged and light-centered, but not ocellate; body bands 3 or 4 (a 4/5 band count is found in one specimen), sometimes broken up on posterior part of body or faint in young (or long-preserved?) specimens, prominently dark-edged and somewhat sinuous. Coloration in life: dorsal ground color yellowish gray, brightest on neck and shoulders; ground color of dorsum of head pale yellowish gray; collar black-edged with yellowish gray center which has a few scattered yellow dots just posterior to the anterior black edge; body bands black-edged becoming gray posteriorly, center of bands always with a few scattered yellow dots; dorsa of limbs yellowish gray—flecked and mottled with tan; venter grayish, with gray flecking on infralabials and throat.

Males heavily spotted with very dark brown on a light yellowish-tan ground color; head distinctly more yellowish than body; ground color of tail bright yellow (notes based on coloration of type and paratypes of *drapetiscus*: Schwartz, 1958).

Range. Known from the northern portions of Habana and Matanzas province (probable records from Cotorro and Camoa have been noted under the range of *torrei*), and from the southwestern coast of Oriente Province near Cabo



Figs. 18-19. Fig. 18. *Sphaerodactylus intermedius*, dorsal views of two females: A, AMNH 77763, 2 mi E Playa de Guanabo, Cueva de Rincón de Guanabo, Habana Province, Cuba; B, AMNH 94550, 10.5 mi NE Matanzas, Matanzas Province, Cuba. Fig. 19. S. *ruibali*, dorsal views: A, ASFS V6252, male, east side, Guantánamo Bay, U. S. Naval Base, Oriente Province, Cuba; B, female, UMMZ 110181, U. S. Naval Base, Oriente Province, Cuba.

Cruz (Fig. 6). The records from the latter area may well represent a distinct population.

Remarks. The type and paratype of *intermedius* have a very obscure body pattern but a bold neck and head pattern. Upon discovering that S. *cinereus* changes from a boldly banded juvenile ("*elegans*") to the more uniformly colored adult, Barbour (1923) concluded that *intermedius* had been based only on a transitional stage of this metachrosis and was therefore a synonym of *cinereus*, where the name remained hidden until the present study. *Sphaerodactylus cinereus* in the banded phase does not have the characteristic head pattern of *intermedius* but has a simpler one similar to that of S. *decoratus*. There is no doubt that *intermedius* is a close relative of *decoratus* (and other members of the group); but because of its radically different head pattern along with other significant pattern differences we have accorded it species status, which we have little doubt that it deserves. Of note are two specimens, MCZ 8510 from Cabo Cruz and USNM 81670 from Río Puerco, both of which are near the extreme southwestern tip of Oriente Province. (One of these specimens (MCZ 8510) is figured in dorsal aspect by Barbour and Ramsden (1919:Plate 2, Fig. 1), although it is not the type of S. *torrei*, as stated there.) We consider both to represent S. *intermedius*. They are old and faded but are banded and possess the distinctive head pattern of *intermedius*, including the double postocular stripes which are but faintly visible. Due to their somewhat distinctive patterns it is probable that they represent another race of the species, but we are reluctant to propose a new name because of the difficulty of being sure what features are due to fading and poor preservation, and what are natural. An additional difficulty is the possibility that *intermedius* and *ruibali* are derivative forms as evidenced by some similarities in their patterns (Fig. 20). In such a case the population represented by the southwestern Oriente specimens might be most significant and should not be described until its variation can be sufficently known.

Specimens examined. Cuba: Matanzas Province: MCZ 12305, 13726 (type and paratype of *intermedius*), Sierra de Hato Nuevo between Hato Nuevo (Martí) and Sabanilla de la Palma; UMMZ 78486, ANSP 16359 (paratype of *drapetiscus*), Matanzas; AMNH 94550, 10.5 mi NE Matanzas; **Habana Province:** AMNH 77759-63, 77765, 81367-71 (type and paratypes of *drapetiscus*), AMNH 94264, 2 mi E Playa de Guanabo, Cueva de Rincón de Guanabo; **Oriente Province:** MCZ 8510, Cabo Cruz; USNM 81670, Río Puerco.

Sphaerodactylus ruibali Grant

Sphaerodactylus ruibali Grant, 1959, Herpetologica, 15(1):53. Type locality, U.S. Naval Base, Guantánamo, Oriente, Cuba, type specimen UMNH 44246.

Definition. Dorsal scales small, obtuse to rounded, only slightly swollen, smooth and moderately but uniformly imbricate; dorsals, axilla to groin, 42-60, mean 49.5; few large hair-bearing organs (3 hairs) on posterior tip of dorsal scales; ventral scales smooth, flattened, rounded imbricate; axilla to groin, 30-41, mean 34.8; midbody scales 69-82, mean 75.2. Fourth toe lamellae 6-11, mode 10; upper labials to mid-eye, 3-5, mode 4; one internasal in all specimens. Escutcheon in fully adult specimens with large central area and slender extensions length of thighs, escutcheon scales not infrequently somewhat pigmented (dimensions 5-10 X 19-28). Habitus moderate, snout relatively short and broad, size moderate, to 32 mm snout-vent.

Female coloration (Fig. 19): Dark loreal stripe continues as inferior postocular stripe to level of ear where it meets with dark transverse head stripe that passes behind ear; superior postocular stripes (not always present) proceed for short distance on top of head and stop before meeting transverse head stripe. Pair of dark transverse stripes on neck appear to be cognates of neck stripe in other members of the *decoratus* group; no median snout stripe or interocular dark area present. Body mottled with dark brown irregular markings, which sometimes tend to form irregular ocelli, on tan or light brown ground color. Sometimes there are indications of a transverse dark stripe on anterior body just posterior to axilla; tail dull yellow with some brown mottlings or reticulation. Venter light gray; underside of tail dull yellow. Iris color light gray or gray in life.

Male coloration (Fig. 19): Male loses head and neck banding of female-juvenile pattern with maturity. Head becomes nearly uniform yellow-brown; body color becomes yellow-brown to gray with fine brown specklings or vermiculations. In life, venter is light gray, tail yellow above and below with fine dark mottling above. (Colors from field notes on specimens in life.)

Range. Although not always so stipulated, the naval base records are presumed to be from the east side of the bay (this is known to be true for the MCZ specimens). The known range therefore extends from the east side of the Bahía de Guantánamo to the Río Yateras (Fig. 11), the mouth of which is roughly ten miles east of the bay.

Remarks. The flattened and more imbricate dorsal scales of *ruibali* distinguish it from other members of the *decoratus group.* This scale type, however, is not very far removed from that shown by members of the group and probably represents an early stage in the development of the flattened, more strongly imbricate scales of some species in the genus. The simplified pattern remnants of *ruibali* are reminiscent of those found in *intermedius*: the postocular pattern, the transverse head pattern extending to behind the ear instead of ending just behind the eyes, and the prominence of the neck and anterior body pattern versus that of the rest of the body (very similar to some specimens of female *intermedius* in which the body pattern is much broken up but the head, neck, and scapular patterns are very bold). It is possible that *ruibali* may be an *intermedius* derivative in eastern Oriente.

Several specimens of *S. ruibali* were collected by the senior author at a locality where *S. decoratus* was also taken. However, *ruibali* was found in a more exposed and drier area than were the *decoratus* which were taken in a well-watered nursery.

Specimens examined. Cuba, Oriente Province: UMNH 44246 (type), 44247-49 (paratypes), MCZ 67380-81, 68733-35, 68931-35, 69436-37, 69439, 69442, UMMZ 110181, U.S. Naval Base, Guantánamo; ASFS V6252-55, east side, Guantánamo Bay, U.S. Naval Base; USNM 78921-22, Río Yateras.

HABITAT

Sphaerodactylus decoratus: In the Bahamas some differences in habitat preferences were observed for *decoratus* on the various islands. On South Bimini *flavicaudus* was found almost exclusively in a beach habitat of low dunes where specimens were taken in litter from *Thrinax* palms. On Andros our experience was less extensive but specimens were also found in beach areas or immediately behind beaches and in association with *Cocos* and *Sabal* trash. On Eleuthera specimens of *S. d. atessares* were also most easily collected in sandy beach areas, par-

ticularly in piles of *Cocos* trash or around bases of *Thrinax*. However, the species is apparently more widespread (but rarer) in other situations; one was taken in arid scrub on the southern portion of the island and two others, although taken in a stand of *Thrinax*, were in a coastal limestone scrub, which is not a beach habitat. On Andros, Bimini and Eleuthera *S. notatus* was more widespread than *S. decoratus* and was found both in beach and interior situations. On Great Exuma *S. d. decoratus* was apparently more widespread and was often seen in the interior of the island, usually in piles of rocks. It was most easily collected in the beach situation where palm trash was available. This is in contrast to the aforementioned islands where, despite intensive collecting in interior localities, virtually no specimens were seen. On Cat Island two specimens were taken at night near a light on a plaster-walled house. On Long Island most specimens were taken in a solution hole planted in bananas but others were taken under rocks in shady areas.

Our only experience with Cuban *decoratus* was with *S. d. strategus*, which was collected in a very xeric region but found most abundantly in the artificially moist microhabitat of a well-watered nursery on the U.S. Naval Base. Specimens were taken by moving flowerpots and many more were seen than were collected. Also collected in the same situation were *Amphisbaena cubana* and *Eleutherodactylus atkinsi*. Only one specimen was taken in a more xeric situation along the coast. As to the northern habitat of the races, little or nothing is available. However, we know that the country is generally more mesic in northern Oriente, and Grant (1960) stated that the Banes and Preston area was "forested and humid," which we may presume forms the habitat for *S. d. granti*. The types of *lissodesmus* were taken in a rotten log in forest. The Sierra de Cubitas is in general a mesic area.

Sphaerodactylus alayoi: No habitat notes are available for this species but if the specimens came from the U.S. Naval Base, they were probably taken in xeric surroundings.

Sphaerodactylus torrei: Of the specimens of the nominate race collected by the junior author and company, two were taken in a motel room; three were found in a stone wall in relatively mesic but open surroundings, and those from Playa Juraguá in coastal arid forest. Male specimens of *torrei* that we have included in the race *ocujal* were reported by Cooper (1958) as coming from a coastal sea-grape (*Coccoloba*) situation, where they were taken in "rocks, dried leaves, and other plant debris."

Sphaerodactylus intermedius: This type and paratype of this species were described by Barbour (1921) as having been collected "under loose stones on a dry, rather scrubby, hillside pasture." Schwartz (1958, on the type series of *drapetiscus*) described taking the species "under rocks on the ground" at the base of limestone cliffs; the situation was in "typical tropical deciduous woods with scattered palms." The specimen from northeast of Matanzas was taken in leafy trash at the base of a small tree on a cleared beach.

Sphaerodactylus ruibali: The type series of this form was reported as having been taken in grassy hills at about 300 feet elevation (Grant, 1959b). The specimens collected by the senior author were found adjacent to the nursery described above for *S. d. strategus*. However, the *ruibali* were taken in an exposed area where they were found under scattered rocks and in a rather thin and spotty covering of leaves; none was seen in the moist nursery.

Sphaerodactylus stejnegeri: Although we have had no first hand experience with this species, it apparently is capable of enduring a variety of habitats. The "bridge over the Rivière de l'Artibonite," whence we examined specimens, is a mesic situation, and the Cul-de-Sac is in general dry and desert-like, but the species may occur in oasis situations there. Seven specimens from Eaux Gaillées (MCZ 59488-94) have as part of their collecting data that they were taken on a large tree. Mertens (1939:42) noted that the only *S. stejnegeri* he collected was on the wall of a house in the late afternoon.

CONCLUSIONS

The granular scaled forms have been regarded as more primitive members of the genus (Barbour, 1921:218; King, 1962:42), and probably correctly so. The evidence seems to indicate that forms with more specialized scale types have arisen on different occasions from the granular scaled ones. Thus, of the Cuban members of the *decoratus* complex, *S. torrei* shows a dis-

tinct trend toward flattening and imbrication of the scales. This, coupled with the striking similarity in patterns of *S. stejnegeri* to *S. torrei*, leads us to believe the two to be derivative forms. This is borne out in the scalation of *stejnegeri* which is a degree further advanced beyond *torrei* in flattening and imbrication of body scales (it may be further noted that of the Cuban forms, *torrei* possesses less keeling than the others and that keeling is lacking in *stejnegeri*). The distributional picture supports this conclusion. *S. torrei* is apparently a wholly eastern Cuban species and *S. stejnegeri* is a wholly western Hispaniolan one, and perhaps primarily a northwestern one at that (although it reaches the Cul-de-Sac Plain, it has apparently not exploited this natural channel into the Dominican Republic).

Although we are less certain about the affinities of *S. ruibali*, on the basis of head patterns (Fig. 20) its relationships may well lie with *S. intermedius*. If such is the case, once again we see a progression toward flattening and imbrication of the dorsal scales. At the same time there can be little doubt that *S. intermedius* and *S. decoratus* are derivative forms; it is probable that the former partakes of a relict distribution, as it is found in western Cuba and southwestern Oriente. Of note is the occurrence of other relict or apparently relict forms in the same general region of Oriente. Thus *Leiocephalus raviceps* has two races in southeastern and eastern Oriente and another apparently disjunct in Matanzas Province (Schwartz, 1960); and *Cricosaura typica* is a relict Cuban xantusiid known only from extreme southwestern Oriente (Savage, 1964).

Sphaerodactylus torrei is presumed to have arisen as an isolate on the southern coastal slopes of the Sierra Maestra. If we have interpreted the three-banded subspecies *ocujal* correctly, the close affinities of *torrei* with *decoratus* are certain. *S. t. ocujal* is the most distal race from the present area of contact between *S. decoratus* and *S. torrei*, and, unless contact with northern (as opposed to eastern) *decoratus* existed around the western end of the Sierra Maestra, is the most isolated of the races of *torrei* from the presumed ancestral form. This relative isolation may account for the retention of the more primitive color pattern (greater number of body bands). Present records indicate that the primary distribution of *S. decoratus* in Cuba is the north of Oriente Province. It probably occurs to the east of the Bahía de Guantánamo and is possibly continuous peripherally with the north coast populations around Cabo Maisí. *Sphaerodactylus d. lissodesmus* is the westernmost representative of the species and may be endemic to the Sierra de Cubitas. *Sphaerodactylus alayoi* is certainly a close relative of *S. decoratus*, but so little is known of its

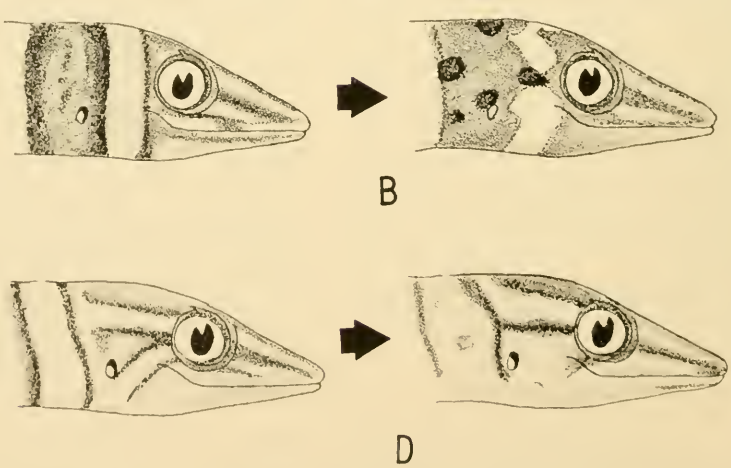


Fig. 20. Lateral views of heads of four geckos to show hypothetical evolution of pattern from generalized *decoratus*-type head pattern through *intermedius* to *ruibali*: A, *S. decoratus granti* (BYU 17232); B, *S. decoratus* subsp. (MCZ 42281); C, *S. intermedius* (AMNH 81367); D, *S. ruibali* (MCZ 67380). The Cat Island specimen of *S. decoratus* (B) shows a pattern variant which demonstrates the possible method of origin of the *intermedius-ruibali* head pattern.

distribution that no explanation of its origin can be hazarded (and for that matter, its status must also remain in slight doubt). The presumptive *intermedius-ruibali* relationship may reflect an older subgroup of this complex, as indicated by (1) a high degree of divergence, and (2) a relict distributional pattern.

Sphaerodactylus decoratus as here defined includes both Bahaman and Cuban races. Some might prefer that these two geographical groups be regarded as separate species. However, we believe that on the basis of geographical proximity and similarity of coloration and scalation of the two that we have made the choice that best expresses their relationships. The diversity of *decoratus* in the Bahamas themselves, less in degree than that which has occurred in the group in Cuba, is attributable to the recency of the present Bahaman land configuration and probably also to its variability. The herpetofauna of the Bahamas north of the Crooked Island Passage is primarily Cuban in origin and the degree of endemism is not generally great. It has been postulated that the Bahamas were colonized from Cuba by dispersal across water rather than by direct connection with Cuba (Clench, 1938; Rabb and Hayden, 1957), as there is presumed to have been no continuous land connection between the two areas. *Sphaerodactylus decoratus* is absent from the Little Bahama Bank and the islands south of the Crooked Island Passage. Both of these divisions are occasions for distinct (but not absolute) faunal breaks in the Bahamas. Rum Cay is separated from the Great Bahama Bank by deep water (about 1500 fathoms) and is the only island to which *S. decoratus* has spread beyond the Great Bank.

Puerto Rico has no members of this group, nor apparently does Jamaica (we have not had first-hand experience with *S. oxyrrhinus*, but it does not seem to pertain to the *decoratus* group). The group is also not represented in the Lesser Antilles; with the possible exception of *S. cinereus* (see below) it is not represented on Hispaniola except by *S. stejnegeri*.

Sphaerodactylus cinereus has not been considered a member of the *decoratus* complex in this study because of its differences in coloration, lack of sexual dichromatism, and scalation (of all the forms we have seen it probably comes closest to having truly granular scales). If in the future it should be considered to belong to the group, its distribution fits well with the concept of a Cuban origin of the complex. It is widespread on Cuba (but uncommon in Oriente Province) but restricted to western Hispanola, although in contrast to the similarly ranging *torrei-stejnegeri* pair, differentation between the populations of the two islands appears to be slight in this species.

Thus, the distributional picture presented by the *decoratus* group of sphaerodactyls is one of a principally Cuban radiation in which limited dispersal to nearby islands and island groups has occurred. The great diversity of forms in Cuba indicates a long history of the group there. That diversification has been greatest in eastern Cuba is perhaps explained by the physiographic and ecological complexity of this region.

Cuba is generally well represented by *Sphaerodactylus* and has more (and more diverse) species than any other West Indian island, including members of the *scaber* group characterized by large dorsal scales and a middorsal zone of granules, and *S. notatus*, which belongs to a loosely defined assemblage including forms (such as *S. difficilis* and *S. inaguae* and perhaps the Puerto Rican forms) having uniformly flattened, keeled and comparatively large dorsal scales. *Sphaerodactylus ramsdeni*, a local adaptation to the montane forest gecko niche, is probably derived from one of the other "groups" on the island. *S. argus* of Jamaican origins shows a restricted but apparently natural distribution in Cuba and is probably a comparatively recent arrival.

LITERATURE CITED

Barbour, T. 1914. A contribution to the zoögeography of the West Indies, with especial reference to amphibians and reptiles. Mem. Mus. Comp. Zool., 44(2):207-359.

———. 1921. *Sphaerodactylus*. Mem. Mus. Comp. Zool., 47(3):218-278.

——— and C. T. Ramsden. 1919. The herpetology of Cuba. Mem. Mus. Comp. Zool., 47(2):71-213.

Clench, W. J. 1938. Origin of the land and freshwater mollusk fauna of the Bahamas, with a list of species occurring on Cat and Little San Salvador Islands. Bull. Mus. Comp. Zool. 80(14):481-541.

Cochran, D. M. 1924. Notes on the herpetological collections made by Dr. W. L. Abbott on the island of Haiti. Proc. U. S. Nat. Mus., 66(6):1-15.

———. 1934. Herpetological collections from the West Indies made by Dr. Paul Bartsch under the Walter Rathbone Bacon Scholarship, 1928-1930. Smithsonian Misc. Coll., 92(7):1-48.

———. 1941. The herpetology of Hispaniola. Bull. U. S. Nat. Mus., 177:a-vii, 1-398.

Cooper, J. E. 1958. Ecological notes on some Cuban lizards. Herpetologica, 14(1):53-54.

Grant, C. 1937. Herpetological notes with new species from the American and British Virgin Islands, 1936. J. Dep. Agr. Puerto Rico, 21(4):503-522.

———. 1956. The status of *Sphaerodactylus gibbus*. Herpetologica, 12(3):247-248.

———. 1958. A new gekkonid lizard (*Sphaerodactylus*) from Cuba. Herpetologica, 14(4):225-227.

———. 1959a. A new *Sphaerodactylus* from Guantanamo, Cuba. Herpetologica, 15(1):49-53.

———. 1959b. Another new *Sphaerodactylus* from Guantanamo, Cuba. Herpetologica, 15(1):53.

———. 1960. Differences in shade of some reptiles from the north and south coasts of Oriente, Cuba. Herpetologica, 16(3):174.

Hecht, M. K. 1954. The comparison of recent and fossil amphibian, reptilian, and mammalian faunas in the Bahamas. Year Book Amer. Phil. Soc., pp. 133-135.

King, W. 1962. Systematics of Lesser Antillean lizards of the genus *Sphaerodactylus*. Bull. Florida State Mus., 7(1):1-52.

Mertens, R. 1939. Herpetologische Ergebnisse einer Reise nach der Insel Hispaniola, Westindien. Abh. senckenberg. naturf. Ges., 449:1-84

Rabb, G. B. and E. B. Hayden. 1959. The Van Voast-American Museum of Natural History Bahama Islands Expedition record of the expedition and general features of the islands. Amer. Mus. Novitates, 1836:1-53.

Savage, J. M. 1964. Studies on the lizard family Xantusiidae. V. *Cricosaura typica* Gundlach and Peters. Copeia no. 3:536-542.

Schwartz, A. 1958. A new gecko of the *Sphaerodactylus decoratus* group from Cuba. Proc. Biol. Soc. Washington, 71:27-36.

———. 1960. Variation in the Cuban lizard *Leiocephalus raviceps* Cope. Proc. Biol. Soc. Washington, 75:67-82.

Thomas, R. and A. Schwartz. 1966. *Sphaerodactylus* (Gekkonidae) in the Greater Puerto Rico region. Bull. Florida State Mus., 10(6):193-260.

Wetmore, A. and B. H. Swales. 1931. The birds of Haiti and the Dominican Republic. Bull. U. S. Nat. Mus., 155:1-483.

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